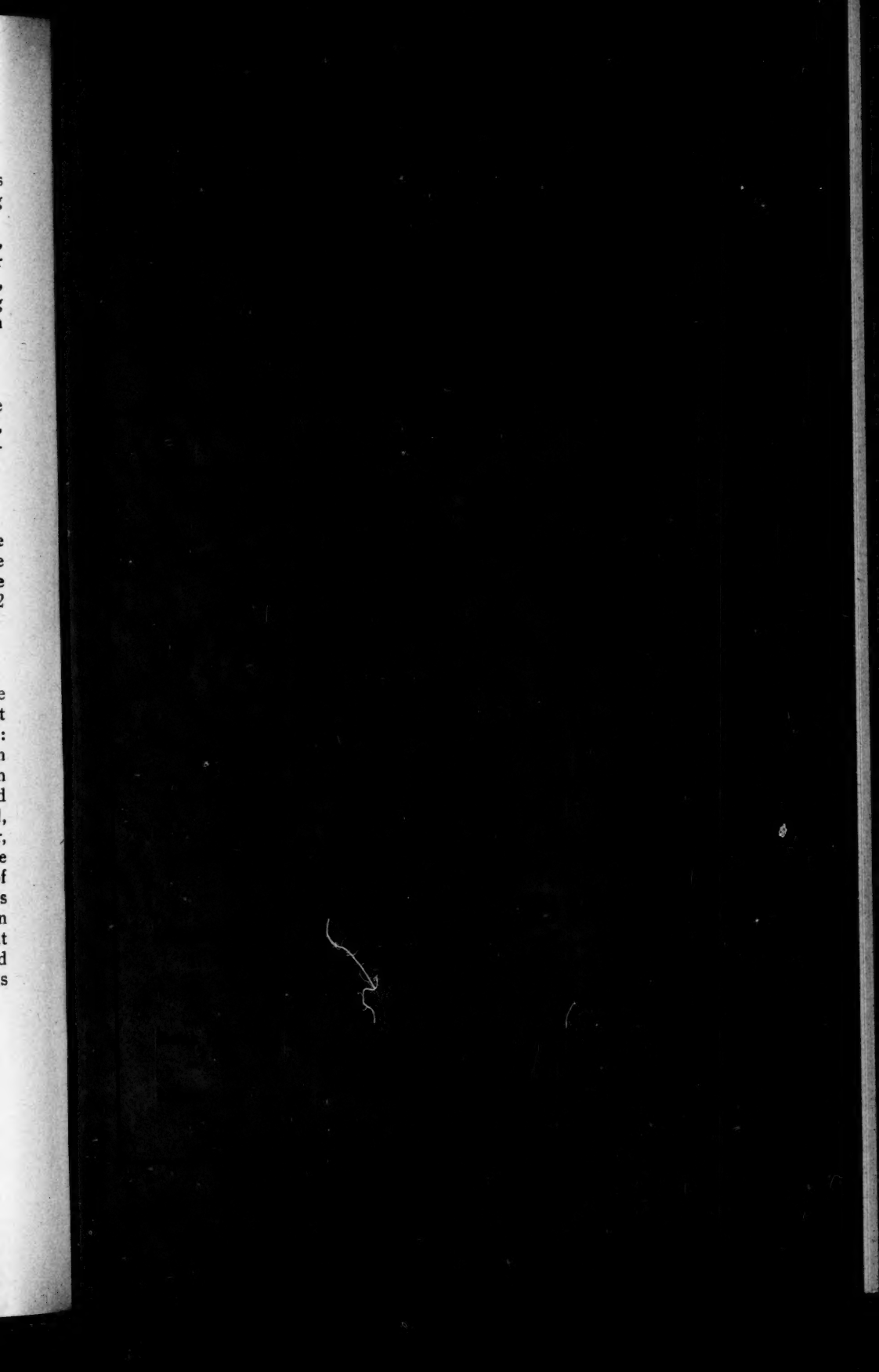

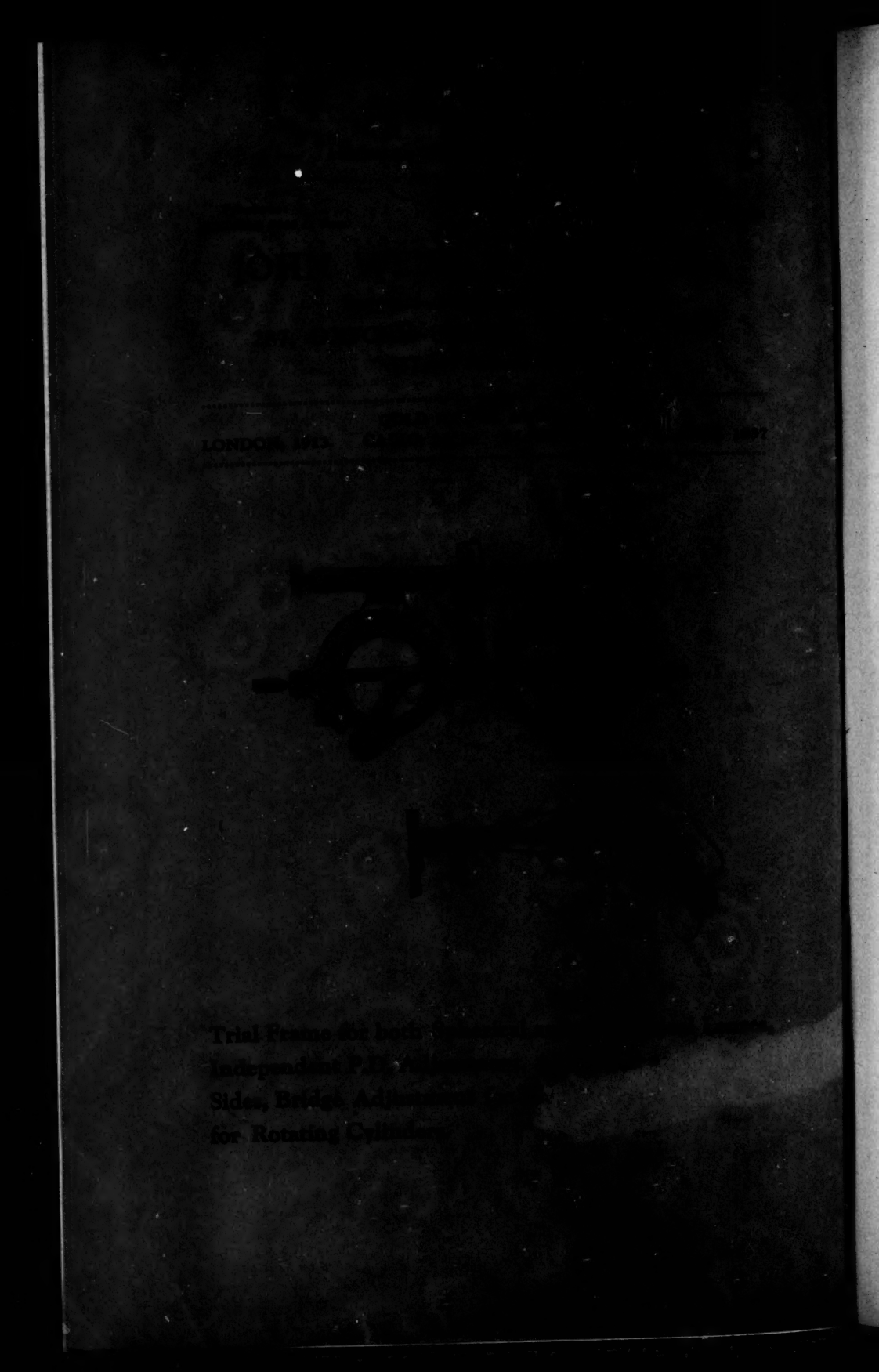

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COMMUNICATIONS

DISTRIBUTION OF PENICILLIN IN THE EYE AFTER SUBCONJUNCTIVAL INJECTION*

BY

ARNOLD SORSBY *and* J. UNGAR

LONDON

ADEQUATE intra-ocular concentrations of penicillin can be reached by both systematic administration of massive doses (Struble and Bellows, 1944; Town, Frisbe and Wisda, 1946; Town and Hunt, 1946 and Sorsby and Ungar, 1946) and by the application of highly concentrated ointments and subconjunctival injections (Sorsby and Ungar, 1946. In a previous study we indicated that the highest and most persistent intra-ocular concentration is obtained by means of subconjunctival injection especially when combined with adrenalin; the first of these findings has been confirmed and extended by Andrews (1947) and the second by the data recorded in the present communication.

The technique employed is that recorded in our earlier study.

* Received for publication, July 7, 1947.

Cocaine analgesia is used. Each of our values represents the average of two findings, which generally showed a close approximation. Where adrenalin was used, a solution 1 : 1,000 was the solvent employed instead of water.

Experimental data

1. *Preliminary experiments on the effect of adrenalin.*—Table I shows the intra-ocular levels reached on the subconjunctival injection of 20,000 units of penicillin with and without adrenalin. Though there are slight discrepancies the following conclusions seem valid :—

(1) One hour after injection the level of penicillin in the various intra-ocular tissues is generally rather higher where adrenalin had been used.

(2) After 3 hours the difference is more distinct. Where adrenalin had not been used penicillin tends to disappear from the eye. In contrast substantial intra-ocular levels are present where adrenalin was employed.

(3) Both these findings are reflected in the uninjected eye: where adrenalin has been used the intra-ocular levels are rather higher and definitely more persistent.

It would therefore seem that adrenalin acts by preventing the rapid elimination of the penicillin from its subconjunctival depot.

2. *Effect of dose on intra-ocular levels.*—When 50,000 units of penicillin are injected subconjunctivally the intra-ocular levels reached are generally considerably more than $2\frac{1}{2}$ times those obtained with 20,000 units, as can be seen from a comparison of the corresponding data in Table I. Moreover it would seem that the levels reached are more persistent.

The following summary table brings out some of the salient features.

Subconjunctival injection	Level in									
	Aqueous		Vitreous		Cornea		Anterior uvea		Posterior uvea	
At	1 hr.	3 hrs.	1 hr.	3 hrs.	1 h.	3 hrs.	1 hr.	3 hrs.	1 hr.	3 hrs.
20,000 units ...	10·0	0·06	0·5	Trace	>30	0·8	>6·1	0·375	11·5	0·38
50,000 units ...	17·0	3. 0	5.0	1·50	76	18·75	70·0	8·75	140	11·25

This disproportion is emphasised when the values obtained for injection with adrenalin are examined, as can be seen from the following summary table.

Subconjunctival injection with adrenalin	Level in									
	Aqueous		Vitreous		Cornea		Anterior uvea		Posterior uvea	
At	1 hr.	3 hrs.	1 hr.	3 hrs.	1 hr.	3 hrs.	1 hr.	3 hrs.	1 hr.	3 hrs.
20,000 units ...	1·0	0	2·0	0·125	>80	>10	>14	>3	>32	>8
50,000 units ...	>32·0	> 20	17	0·5	>1,440	450	775	60	>750	20

3, *Effect of adrenalin on intra-ocular levels.*—Comparison of the data in Tables II and III shows the marked effect of adrenalin in raising the intra-ocular levels of penicillin. The effect is apparent within a quarter of an hour and would appear to be maximal at 2—3 hours, declining after that, so that at 6 hours the adrenalin values are generally of the order of twice those obtained without adrenalin.

The following summary table and figs. 1—4 bring out some salient features.

Penicillin levels

At	¼ hr.	1 hr.	2 hrs.	3 hrs.	6 hrs.
Aqueous					
without adrenalin ...	24	17	9	3	0·56
with adrenalin ...	>32	>32	>32	>20	1·25
Vitreous					
without adrenalin ...	7	5	1·5	1·5	0·06
with adrenalin ..	>17	17	5·0	0·5	0·03
Cornea					
without adrenalin ...	950	76	25·0	18·75	1·5
with adrenalin ...	>860	>1440	925	450	2·5
Anterior uvea					
without adrenalin ...	160	70	1·25	8·75	0·34
with adrenalin ...	>290	>775	510	60	0·6
Posterior uvea					
without adrenalin ...	200	140	9·5	11·25	1·12
with adrenalin ...	>550	>750	230	20	0·6

TABLE I

Comparison of the Distribution of Penicillin in Ocular Tissues *after Subconjunctival Injection* of 20,000 units Pure Penicillin with and without Adrenalin.

	Penicillin levels in units per c.c. of fluid or per gm. of tissue			
	1 hour after injection		3 hours after injection	
	Without adrenalin	With adrenalin	Without adrenalin	With adrenalin
INJECTED EYE				
Aqueous	10	1·0	0·06	0
Vitreous	0·5	2·0	Trace	0·125
Cornea	>30	>80	0·8	>10
Lens	*0·25*	*1·0*	*0*	*0·06*
Anterior sclera ...	>7·5	>12	0·95	>4
Posterior sclera ...	>12	>12	1·25	>4
Anterior uvea ...	>6·1	>14	0·375	>3
Posterior uvea ...	*11·5*	*>32*	*0·38*	*>8*
Optic Nerve... ...	1·0	1·0	0	0·5
Extra-ocular muscles	>18	12	0·75	>4
BLOOD	4·5	8	0	1
UNINJECTED EYE				
Aqueous	2·125	1·0	0	0
Vitreous	0·03	0·25	0	0·125
Cornea	0·487	1·25	0·63	*3·5*
Lens	*0·03*	*0*		0·125
Anterior sclera ...	1·32	3·0	0·5	3·5
Posterior sclera ...	0·84	1·5	1·25	>4
Anterior uvea ...	0·3	0·25	0·09	0·6
Posterior uvea ...	0·15	4	0·18	1·5
Optic Nerve... ...	0·125	0·5	0	0
Extra-ocular muscles	0·37	4	Trace	1·2

TABLE II

Distribution of Penicillin in Ocular Tissues after Subconjunctival Injection of 50,000 units Pure Penicillin in 0·5 of Distilled Water

	Penicillin levels in units per c c. of fluid or per gm. of tissue						
Hours after injection:	¼ hr.	½ hr.	1 hr.	2 hrs.	3 hrs.	4 hrs.	6 hrs.
INJECTED EYE							
Aqueous	24	19	17	9	3	0·75	0·56
Vitreous	7	2·5	5	1·5	1·5	0·12	0·06
Cornea	950	97	76	25	18 75	4 87	1·5
Anterior sclera ...	>660	380	120	11	16	7·25	2
Posterior sclera ...	580	450	153	30	15·4	8·5	2
Anterior uvea ...	160	60	70	1·25	8·75	4·2	0·34
Posterior uvea ...	200	110	140	9·5	11·25	Trace	1·12
Extra-ocular muscles	310	140	140	23·75	17·5	9·5	1
BLOOD	16	16	8	0·35	0	0	0
UNINJECTED EYE							
Aqueous	2	2	1	0·5	0·25	0	0
Vitreous	0·5	0·12	0·25	0·12	0	0	0
Cornea	4	4	4	1	1·5	0	0
Anterior sclera ...	1	1	1	0·5	0·6	0·3	0·3
Posterior sclera ...	3	3	1·5	1·5	1·4	0·8	0·4
Anterior uvea ...	2·5	2·5	1·25	0	0	0	0
Posterior uvea ...	5	2·5	2·5	0	0·1	0	0
Extra-ocular muscles	6	6	4	0	0	0	0

Fig. 5 shows graphically the levels reached with adrenalin.

4. *Effect of adrenalin on blood-level.*—From Table II it would appear that where adrenalin is not used, the maximum blood level is reached within half an hour, after which it rapidly declines

to zero by the end of the second hour. Where adrenalin is used (Table III), lower but more persistent levels are reached. The following summary table and the revelant graphs in Figs. 1 and 3 bring out the salient features.

TABLE III

Distribution of Penicillin in Ocular Tissues after Subconjunctival Injection of 50,000 units Pure Penicillin in 0·5 ml. of Adrenalin 1 : 1,000

	Penicillin levels in units per c.c. of fluid or per gm. of tissue						
Hours after injection :	¼ hr.	½ hr.	1 hr.	2 hrs.	3 hrs.	4 hrs.	6 hrs.
INJECTED EYE							
Aqueous	>32	>17	>32	>32	>20	20	1·25
Vitreous	>17	>17	17	5	0·5	13	0·03
Cornea	>860	>200	>1,440	925	450	65	2·5
Anterior sclera ...	>290	>285	>450	295	185	50	4·0
Posterior sclera ...	>400	>240	>520	450	96	19	1·25
Anterior uvea ...	>290	>220	>775	510	60	13·5	0·6
Posterior uvea ...	>550	>200	>750	230	20	6·5	0·6
Extra-ocular muscles	>2,200	1,400	1,200	560	92·5	50	9·0
BLOOD	>2	>3	3	1·5	0·75	0·12	0·12
UNINJECTED EYE							
Aqueous	3·25	0·37	0·25	0·5	0·19	0·12	0·3
Vitreous	0·06	0·3	0·06	0·06	0·25	0	0·05
Cornea	2·75	3·75	1·25	0·625	1·2	1·75	0·12
Anterior sclera ...	3·50	1·75	4·4	2·1	0·58	0·75	0·65
Posterior sclera ...	3·8	2·8	3·75	2·1	0·85	0·6	0·7
Anterior uvea ...	5·7	2·25	5·65	0·8	0·33	1·5	0·1
Posterior uvea ...	9·0	3·50	1·25	0·62	1·4	0	0·3
Extra-ocular muscles	9·0	2·65	3·0	3·5	0	0·6	0·25

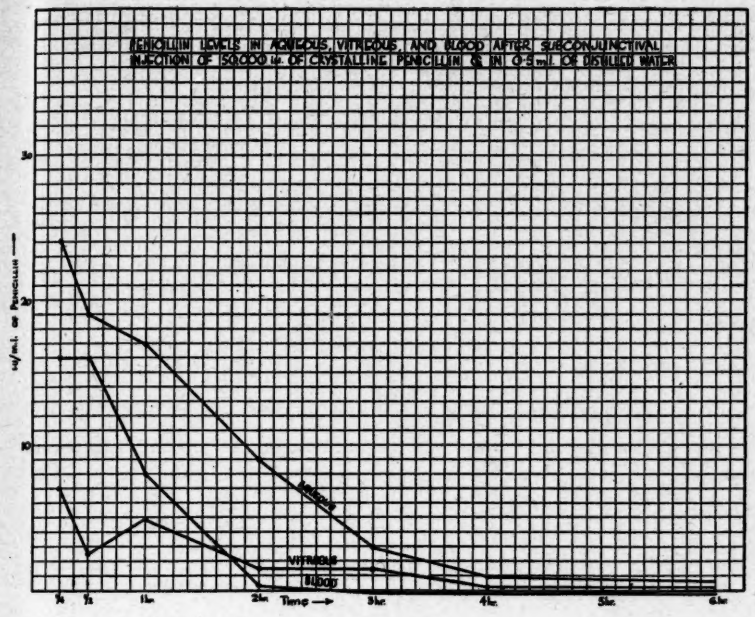
PENICILLIN LEVELS IN AQUEOUS, VITREOUS, AND BLOOD AFTER SUBCONJUNCTIVAL INJECTION OF 150,000 iu. OF CRYSTALLINE PENICILLIN Na IN 0·5 ml. OF DISTILLED WATER
30
20
10
u/ml. of Penicillin
AQUEOUS
VITREOUS
BLOOD
½
1hr
2hr
Time →
3hr
4hr
5hr
6hr

FIG. 1.

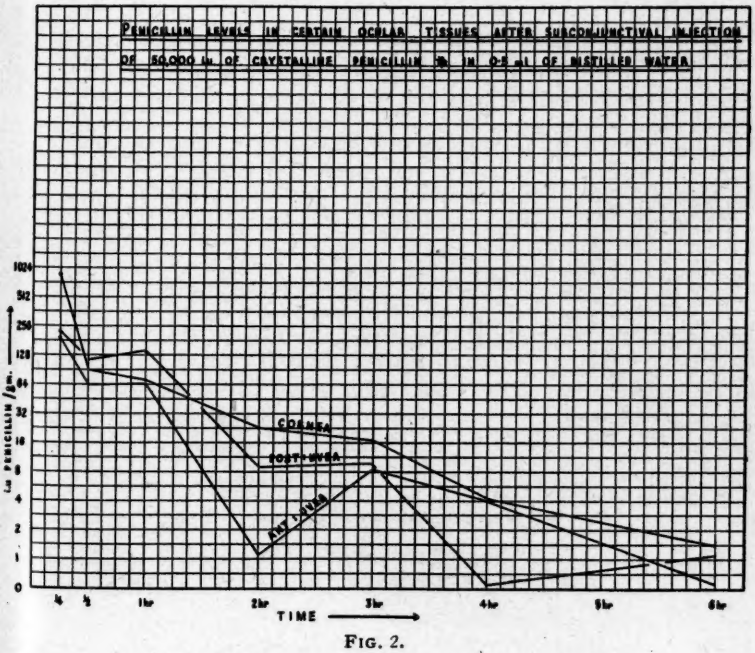
PENICILLIN LEVELS IN CERTAIN OCULAR TISSUES AFTER SUBCONJUNCTIVAL INJECTION OF 50,000 iu. OF CRYSTALLINE PENICILLIN Na IN 0·5 ml. OF STERILE WATER
1024
512
256
128
64
32
16
8
4
2
1
0
Iu. PENICILLIN/gm.
CORNEA
POST-UVEA
ANT.-UVEA
½
1hr
2hr
TIME
3hr
4hr
5hr
6hr

FIG. 2.

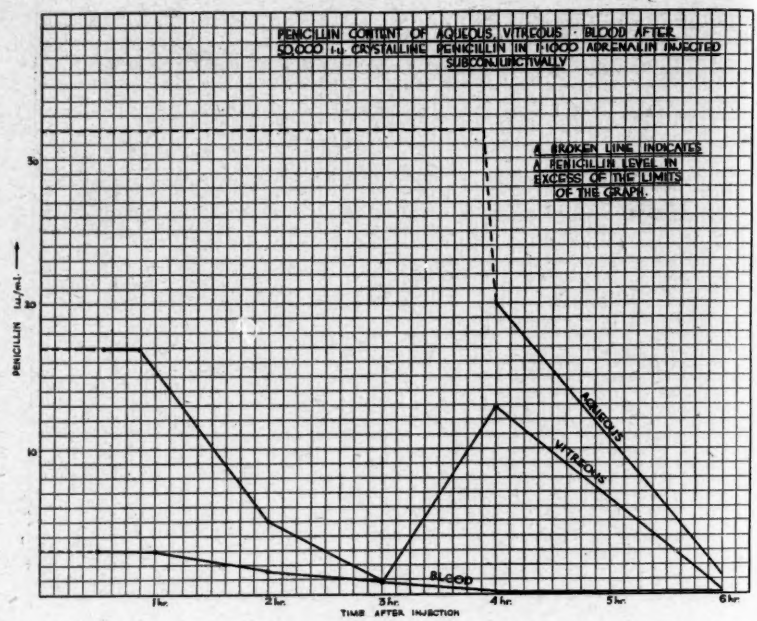
PENICILLIN CONTENT OF AQUEOUS, VITREOUS & BLOOD AFTER 50,000 i.u. CRYSTALLINE PENICILLIN IN 1:1000 ADRENALIN INJECTED SUBCONJUNCTIVALLY
A BROKEN LINE INDICATES A PENICILLIN LEVEL IN EXCESS OF THE LIMITS OF THE GRAPH.
PENICILLIN i.u./ml.
30
20
10
AQUEOUS
VITREOUS
BLOOD
1hr.
2hr.
3hr.
4hr.
5hr.
6hr.
TIME AFTER INJECTION

FIG. 3.

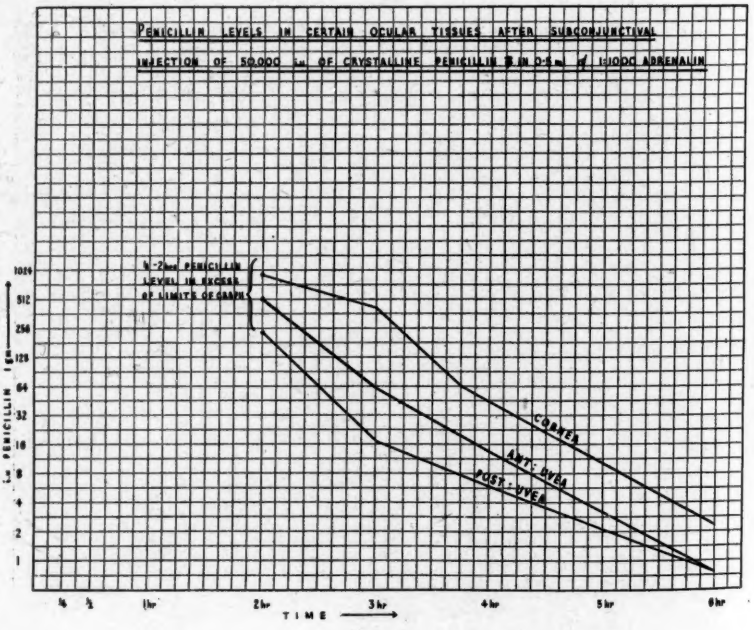
PENICILLIN LEVELS IN CERTAIN OCULAR TISSUES AFTER SUBCONJUNCTIVAL INJECTION OF 50,000 i.u. OF CRYSTALLINE PENICILLIN IN 0·5 ml. of 1:1000 ADRENALIN
½-2hrs PENICILLIN LEVEL IN EXCESS OF LIMITS OF GRAPH
i.u. PENICILLIN 1 gm.
1024
512
256
128
64
32
16
8
4
2
1
CORNEA
ANT. UVEA
POST. UVEA
½
½
1hr
2hr
3hr
4hr
5hr
6hr
TIME

FIG. 4.

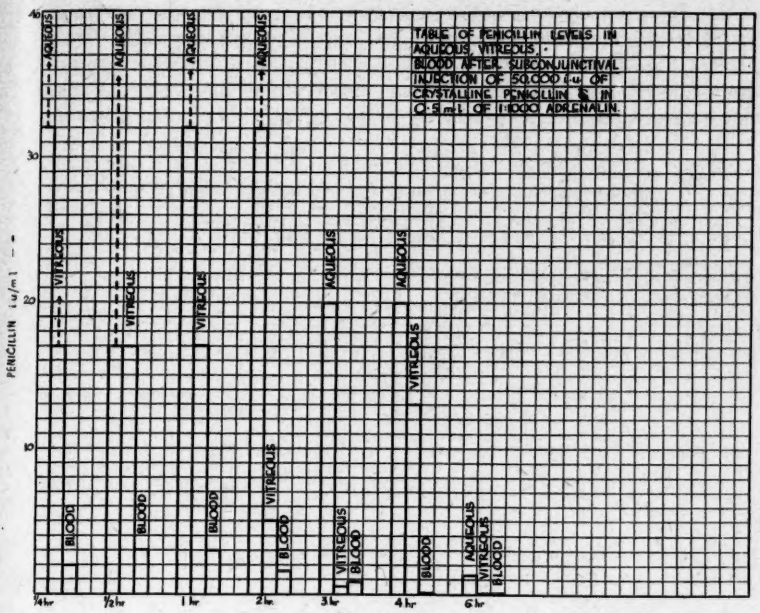

FIG. 5.

Subconjunctival injections of 50,000 units of penicillin	Blood-levels at				
	¼ hr.	1 hr.	2 hrs.	3 hrs.	6 hrs.
Without adrenalin ...	16	8	0·35	0	0
With adrenalin ...	>2	3	1·5	0·75	0·12

5. *Effect of adrenalin on the levels reached in the uninjected eye.*—As can be seen from Tables II and III there is a considerable intra-ocular level of penicillin in the uninjected eye after a massive dose subconjunctivally in the fellow eye. Comparison between the levels reached on the injection of penicillin with and without adrenalin is difficult, as these levels are generally low and rather bizarre. It is, however, clear that intra-ocular levels tend to persist longer when adrenalin is used. When injections are made without adrenalin all the ocular tissues except the sclera are free from penicillin at 4 and 6 hours, whilst fairly substantial levels are still present where adrenalin has been used.

6. *Observations in man.*—When eyes of patients came to excision the opportunity was taken to inject penicillin subconjunctivally at variable intervals before excision. The level of penicillin in the aqueous and vitreous was determined by assay of some aspirated fluid. The following table gives the results obtained.

Level of penicillin in the aqueous and vitreous of human eye after subconjunctival injection of 50,000 units of penicillin in 0·5 c.c. of 2 per cent. novocaine

Patient's Age	Time injected before enucleation	Concentration in		Clinical Condition	Remarks
		Aqueous	Vitreous		
74	½ hour	16	0	Old irido cyclitis	—
12	1 hour	2	0·25	Old intra-ocular foreign body	—
5	1 hour	4	0·125	Old irido-cyclitis	—
27	2 hours	32	0·5	Intra-ocular foreign body. Panophthalmitis	—
55	4 hours	0·5	16	Old injury. Iris bombé	Fluid vitreous

These limited results are consistent with the experimental findings, in so far as they show that adequate therapeutic levels can be reached in both the aqueous and vitreous, and much more readily in the first than in the second.

Discussion

1. *Comparison with previous data.*—Andrews' data, like our preliminary results, have shown that high intra-ocular levels are reached by subconjunctival injection of 50,000 units of penicillin. Though his actual values are consistently lower, the findings recorded by Andrews agree closely with our own. The significant differences in the two studies are that whilst Andrews found the concentration in the vitreous almost uniformly negligible, the concentrations we obtained were therapeutically significant. In our present investigation we ignored the lens, as in preliminary experiments we found the concentration in the lens consistently negligible. Andrews' readings showed rather more positive values.

2. *Comparison of levels reached by subconjunctival injection with those obtained by ointments and systemic administration.*—The only data available are those recorded in our previous study.

It may be recalled that ointments in concentrations of up to 40,000 units/gm. do not maintain any adequate intra-ocular levels after 2½ hours. To a lesser extent this also applies to massive systemic administration. The following summary table brings out salient comparative data on the use of subconjunctival injections, ointment and systemic administration of penicillin.

Concentration at 2 hours after application

	Aqueous	Vitreous	Cornea	Sclera	Uvea
Subconjunctival injections 50,000 units					
Without adrenalin ...	9	1·5	25	20·5	5·37
With adrenalin ...	>32	5·0	925	372·5	370
0·1 gm. of ointment 50,000 U/gm.	2·75	4	0·75	1	0·3
Intravenous injections * 25,000 units	0·37	1	0·5	2	2·06

* After 2½ hours.

Though the values recorded for intra-ocular levels after the application of ointment and after systemic administration are based on few observations, the overwhelming advantages of subconjunctival injections are beyond question.

3. *Factors in the maintenance of intra-ocular levels of concentration.*— The level of concentration of penicillin intra-ocularly depends on the amount of penicillin that reaches the eye, on the amount eliminated either by excretion or destruction, and on the rate at which these processes take place. Of the many factors involved only the dose of penicillin and the addition of adrenalin to the penicillin have so far been isolated. For adequate control of intra-ocular levels an intensive study of other relevant factors is required.

4. *Clinical applications.*—From the data recorded it is clear that an injection of 50,000 units is preferable to one of 20,000 for two reasons: in the first place it gives considerably and disproportionately higher levels of intra-ocular concentration; and secondly, these levels are maintained for a longer period. It is also clear that the solvent used is a matter of some importance. Normal saline is excluded as any substantial amount of penicillin dissolved in such a solution makes it hypertonic (Ungar and Denston, 1946). The advantages of adrenalin have already been indicated. For repeated injections, particularly in an inflamed eye, 2 per cent. novocaine as a solvent has considerable advantages, and there

would seem to be no reason why equal quantities of adrenalin and novocaine should not be used as a solvent for routine purposes. As for the frequency of application, results in the rabbit suggest that when 50,000 units are used injections should be given at intervals of 6 hours.

Summary

1. Substantial concentrations of penicillin in the ocular tissues many times the usual therapeutic level, can be obtained by the subconjunctival injection of crystalline penicillin in a dose of 50,000 units. Adequate levels persist for 6 hours.

2. The concentrations are distinctly higher if adrenalin 1:1,000 is used as the solvent for the penicillin.

3. Observations on 5 human eyes support the findings obtained experimentally.

Our thanks are due to Dr. H. M. Walker of Glaxo Laboratories Ltd., for facilities for the work recorded and to Mr. B. Helliwell for his painstaking technical assistance.

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LOCAL PENICILLIN THERAPY OF HYPOPYON FORMATION: WITH SPECIAL REFERENCE TO THE USE OF SUBCONJUNCTIVAL INJECTION*

BY

ARNOLD SORSBY *and* HOWARD REED

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INDICATIONS for the use of penicillin and optimal methods for its employment locally have still to be determined. Drops require to be instilled at frequent intervals; lamellae have not proved satisfactory and ointments have presented difficulties as to the best base to be employed. For hypopyon ulcer Juler and Young (1945) have found penicillin effective and have advocated the application of solid penicillin to the infected ulcer. The present study on the

* Received for publication, July 7, 1947.

value of penicillin in the different varieties of hypopyon formation also attempts an assessment of subconjunctival injection as a method of application.

Clinical Data

1.—Infected cornea ulcer with hypopyon

1. *Infected corneal ulcer with hypopyon.*—Hardly any of the 39 cases of infected corneal ulcer with hypopyon conformed to the text-book picture of serpiginous ulcer. The ulcer itself was generally irregular in shape, the base and margin being infected to a variable degree; interstitial infiltration around the ulcer was present in 8 cases, whilst iritis was noted in 21 cases, though probably present in a subclinical form in all cases. In only one instance was the pneumococcus found. The clinical data of these cases are shown in Table I.

The following are the salient features:—

1. *Sex distribution.*—There were 30 men and nine women.

2. *Age distribution.*—This is shown in the following summary table.

Age	Number of Cases M.	F.
0- 9	—	—
10-19	2	1
20-29	1	—
30-39	3	—
40-49	2	2
50-59	10	—
60-69	9	5
70 and over	3	1

It will be noted that 28 out of the 39 patients were over 50 years of age.

3. *Trauma.*—In only 18 cases was there a clear history of antecedent trauma.

4. *Organisms.*—In 11 cases no bacteriological examination was carried out and in 9 more it was negative; the remaining 19 cases showed this distribution: staphylococcus albus 11, staphylococcus aureus 6, Morax-Axenfeld bacillus 1, pneumococcus 1.

5. *Degree of hypopyon formation.*—Using the arbitrary designations of minimal, $\frac{1}{4}$ of anterior chamber, $\frac{1}{3}$ and $\frac{1}{2}$ and total, the following distribution was observed:

Minimal	...	...	...	...	13 cases
¼	...	...	...	...	22 ,,
⅓	...	...	...	...	2 ,,
½	...	...	...	...	1 case
Total	...	...	...	...	1 ,,

6. *Response to treatment.*—The following summary table shows that in 12 out of 39 cases there was a poor response to treatment or a relapse after initially satisfactory response. In the successfully treated cases recovery was generally rapid, judging by relatively short duration of in-patient treatment.

Treatment in days					Number of cases
up to 7 days	...	...	...	...	4
8 to 14 days	...	...	...	...	12
15 to 21 days	...	...	...	...	7
22 to 28 days	...	...	...	...	4
Poor response or relapse	...	...	...		12

7. *Response in relation to the patient.*—Three of the 12 patients with poor response or relapse, ultimately gave good functional results, 2 having vision of 6/6 and the third vision of 6/12. Two of these patients (Nos. 19 and 25) showed relapse; in the first patient after subconjunctival injections, in the second after oily drops. Ultimately a satisfactory end result was obtained by exclusive subconjunctival penicillin treatment. The third patient (No. 19) treated initially and unsuccessfully for 48 hours with subconjunctival injection, responded well to combined general sulphonamide and local penicillin therapy.

There are therefore 9 patients to consider. Of these the end results were fairly good in five in so far as useful vision was retained; in three more patients there was extensive opacification of the cornea, and 1 patient lost his eye altogether. Apart from the fact that these 9 patients contained a high proportion of women (4 out of 9) the age distribution and other clinical data were not dissimilar to those of the series as a whole. Three of these patients showed staph. aureus, 1 staph. albus, 1 no organisms and in 4 a culture was not taken. One patient had acne rosacea and one rheumatoid arthritis (Nos. 32 and 33 respectively). There was no history of trauma in three patients.

8. *Response in relation to the mode of treatment.*—As can be seen from Table I, subconjunctival injection was the main (or only) treatment in 21 cases. Other forms of local penicillin treatment were given in 12 more cases, whilst local penicillin treatment

combined with general sulphonamide therapy was employed in 4 cases. In 2 cases general sulphonamide therapy was used exclusively.

The following summary table shows the number of cases responding to treatment in relation to the mode of application.

Duration of in-patient treatment	Subconjunctival injection	Other local penicillin therapy			Combined penicillin and sulphonamide therapy	Exclusive oral sulphonamide therapy
		Concentrated ointment	Drops	Painting		
Up to 7 days ...	2	1	—	—	—	1
8 to 14 days ...	8	—	1	1	1	—
15 to 21 days ...	3	1	—	3	1	—
22 to 28 days ...	4	—	—	—	—	—
Poor response or relapse	4	1	1	3	2	1

Four failures out of 21 cases treated with subconjunctival injections compare favourably with 8 failures in 18 cases treated by other methods. The disproportion is, however, not quite so marked, for one of the failures with combined penicillin and sulphonamide treatment received subconjunctival injections. In all, 25 patients received subconjunctival injections (three also receiving sulphonamides simultaneously—Nos. 33, 34, 36, and one receiving it after unsuccessful application of drops—No. 25); five failed to respond satisfactorily, against 7 out of 16 treated initially by other methods.

That the advantage would indeed seem to lie with subconjunctival injections is suggested from a study of the cases showing poor response, and from the end results as regards vision for the series as a whole.

8. *Cases showing poor response.*—(*a*) *Poor response to subconjunctival injection* (Nos. 18—21). In two of these patients (Nos. 20 and 21) the end result was poor in spite of general sulphonamide therapy in both, and intramuscular penicillin therapy in one, after three days treatment exclusively with subconjunctival injections. In the two other cases the end result was good; in one case (No. 18) full vision was obtained by exclusive subconjunctival therapy after two relapses; in the last case (No. 19) a good result was obtained by the addition of general sulphonamide therapy.

(*b*) *Poor response to other forms of local penicillin therapy.*—(Cases Nos. 24, 25, 31, 32 and 33.) In one case, treated exclusively with concentrated penicillin ointment, the eye came to

excision (No. 24). In one case, treated exclusively with weak penicillin ointment, corneal scarring reduced vision to 6/24 (No. 31). In two further cases (Nos. 32 and 33) treated with weak penicillin ointment, oral sulphonamide had to be administered, combined in one case with one subconjunctival injection. In the one case in this series that did well (No. 25) with resultant vision of 6/12, a good response was obtained only after two subconjunctival injections.

(*c*) *Poor response to sulphonamide treatment.* (Nos. 36, 37 and 39). The end result as to vision in these three cases was H.M., 6/60 and 6/18. As these patients had received a variety of treatment in addition to the sulphonamide therapy (to which they did not respond) it is difficult to indicate which was the favourable factor in the one case with useful vision. It may, however, be of some significance that this patient (No. 36), is the only one of the three who had received subconjunctival injections.

10. *End-results as to vision.*—The following summary table shows the end obtained in the 18 cases treated exclusively by subconjunctival injections, compared with the 14 cases in which no such injections were used. In 7 cases (6 of which were cases with poor response) a variety of treatments had to be combined.

Vision at end of Treatment	Subconjunctival injections		Other methods
	Used exclusively	Together with other treatment	
6/9—6/5 ...	10	2	6
6/18—6/12 ...	1	2	2
6/60—6/24 ...	5 (*a*)	—	4 (*c*)
H.M.—P.L. ...	1	3	1
No. P.L. ...	—	—	1
Not recorded ...	1 (*b*)	—	—
	18	7	14

(*a*) 4 cases had pre-existing visual defect.
(*b*) Cornea clear.
(*c*) One had pre-existing visual defect.

It will be noted that in only 3 out of 18 cases treated exclusively by subconjunctival penicillin was corneal damage sufficiently

severe to reduce vision to less than 6/9. In contrast 7 out of the 14 cases treated by other methods gave an end result of vision less than 6/9.

2.—Hypopyon with herpetic or neuropathic corneal lesion

As can be seen from Table II there were 12 patients—9 men and 3 women—with hypopyon associated with a herpetic or neuropathic corneal lesion. There was an infected corneal ulcer in all but four cases, and the cornea was intact in only one case. All but one patient had some degree of iritis.

The hypopyon was minimal in 5 cases, occupied $\frac{1}{4}$ of the anterior chamber in 3, and 1/3 of the anterior chamber in 4 more. In three patients herpes ophthalmicus was present; one patient had had an alcohol injection into the Gasserian ganglion for trigeminal neuralgia. Dendritic ulcer, or a history of it, was present in five patients. In the remaining three patients the cornea was insensitive. Treatment consisted of sub-conjunctival injections in 8 patients. Penicillin ointment 4-800 units per gram was used in 4 patients, in one of whom the ulcer was also painted with penicillin 2,500 units per c.c. Oral sulphonamide was used in 6 patients, "carbolisation" with methyl salicylate in two, and concentrated penicillin ointment in 7 cases. Generally several modes of treatment were used in combination or in sequence.

In only two patients (Nos. 43 and 45) could the response to treatment be designated as good, though only in relation to the hypopyon and not as regards the end result for vision.

One ended in enucleation, and the corneae in the remaining cases all showed dense leucomata. Recovery was slow. The duration of in-patient treatment was generally prolonged as can be seen from the following summary table.

No. of inpatient days	No. of cases
Up to 7 days	—
8-14 days	1
15-21 days	1
22-28 days	3
29-35 days	3
36-42 days	3
43-49 days	1
50 days and over	3

3.—Glaucomatous eyes with hypopyon

In a series of 5 cases of old-standing glaucoma complicated by hypopyon (Table III), 3 eyes ended in evisceration or enucleation for rapidly developing panophthalmitis; 2 of these three eyes were treated intensively by subconjunctival injections of penicillin in addition to oral sulphonamide. One patient responded unexpectedly well to two subconjunctival injections of 50,000 units of penicillin followed by the instillation of penicillin ointment 8,000 units per gm. for 14 days. One further patient did not respond to penicillin "carbolization" and the application of penicillin ointment 800 units per gram; there was a moderately good response to oral sulphonamide.

4.—Hypopyon iritis

Ten patients present 13 instances of hypopyon iritis, one patient having had a bilateral attack and recurrence in one eye, and another patient had recurrence of a unilateral attack (Table IV). Two of these ten patients showed infected corneal lesions. In them (Nos. 57 and 60), as in the remaining 8 patients, the essential lesion was, however, iritis, generally recurrent. In contrast to the sex distribution in patients with infected corneal ulcers, and with neuropathic keratitis (Tables I and II) there was no difference in the sex distribution in this group, men and women being equally represented. The hypopyon was minimal in 6 eyes, $\frac{1}{4}$ in 5, $\frac{1}{3}$ in one, and $\frac{1}{2}$ in one more.

As can be seen from Table IV response to treatment was good in all but one patient. However, it was only in relation to the hypopyon that response could be regarded as satisfactory. In relation to vision the results were not good in 8 out of the 11 eyes treated. This, however, must be ascribed to the pre-existing iritis rather than to the immediate attack of hypopyon formation, as is suggested by the fact that the 3 patients with a first attack (Nos. 61, 63 and 65)—all young people aged 26, 31 and 25 years respectively—recovered full vision.

The treatment adopted was atropine exclusively in 2 cases, oral sulphonamides in 2, subconjunctival injections in 4, combined local penicillin and oral sulphonamide therapy in 2, and these latter measures with additional measures in 3 more.

TABLE I.—INFECTED CORNEAL ULCER

TABLE I.—INFECTED CORNEAL ULCER

(a) Treated by Subconjunctival injection of Penicillin (50,000 units)

No.	Sex	Age	History of trauma	Culture	Lesion other than infected ulcer	Hypopyon	Response	Days in hospital	Treatment.			End result
									No. of injections	Additional Penicillin Treatment in ointment form. Concentration U/gm. used	Treatment other than Penicillin	
1	M	66	Yes	Staph. albus.	—	¼	Good	7	12	—	—	V = 6/5
2	M	66	Yes	Morax-Axenfeld Bacillus.	Onyx	½	Good	28	14	—	—	Faint corneal nebula V = 6/9
3	M	64	No	Staph. Albus.	—	Minimal	Good	16	2	—	—	V = 6/9
4	F	47	Yes	Staph. Albus.	—	Minimal	Good	8	10	—	—	V = 6/6
5	M	56	No		—	¼		14	7	25,000	—	V = 6/6
6	M	85	No	Staph. Aureus.	—	½	Good	10	10	25,000	—	Cornea practically clear. Died from operation for enlarged prostate
7	M	54	No	Nil	Severe iritis	½	Good	24	2	25,000	—	Faint nebula central. V = 6/12
8	M	68	Yes	Nil	—	1/3	Fair	25	20	50,000	—	Central corneal nebula
9	M	34	No	Pneumo coccus	—	Minimal	Good	12	16	50,000	—	V = 6/9

TABLE 1.—*continued.*

No.	Sex	Age	History of trauma	Culture	Lesion other than infected ulcer	Hypopyon	Response	Days in hospital	Treatment.			End result
									No. of injections	Additional Penicillin Treatment in ointment form. Concentration U/gm. used	Treatment other than Penicillin	
10	M	16	Yes	Not done	Interstitial infiltration	¼	Good	12	16	50,000	—	V = 6/6
11	M	59	No	Staph. Albus.	Interstitial infiltration	Minimal	Good	12	10	100,000	—	Old nebula both V = 6/36
12	M	76	(Spastic entropion)	Staph. Albus.	Severe iritis	¼	Good	14	15	100,000	—	Iris bound down Peripheral nebulae. V = 6/24
13	F	43	(Leucoma since childhood)	Not done	Moderate iritis	Total	Good	20	9	100,000	—	P.L. (as before)
14	M	59	No	Staph. Albus.	Interstitial infiltration	Minimal	Good	12	1	100,000	—	Old mustard gas keratitis. V = 6/36
15	M	40	Yes	Staph. Albus.	Interstitial corneal infiltration and mild iritis	Minimal	Good	7	4	100,000	—	Old nebula. Amblyopic V = 6/60
16	M	65	?	Nil	—	Minimal	Good	11	4	100,000	—	Barely perceptible scar V = 6/24

TABLE I.—*continued.*

No.	Sex	Age	History of trauma	Culture	Lesion other than infected ulcer	Hypopyon	Response	Days in hospital	Treatment.			End result
									No. of injections	Additional Penicillin Treatment in ointment form. Concentration U/gm. used	Treatment other than Penicillin	
17	F	62	4 previous attacks; rheumatoid arthritis	Staph. Aureus.	Severe iritis	½	Fair	25	3	100,000	—	V = 6/9
18	M	45	Yes	Staph. Albus.	—	½	Good but 2 relapses	7	18	50,000	—	Barely perceptible scar
	(*a*)	2nd	admission					16	6	50,000		V = 6/6
	(*b*)	3rd	,,					9	12	50,000		
19	F	18	Yes	Nil	Severe iritis	½	Poor (to penicillin)	19	8	50,000	Oral sulphonamide additional to penicillin after 48 hrs	Barely perceptible scar V = 6/6
20	M	32	Yes	Staph. Aureus.	Interstitial infiltration Severe iritis	½	Poor	77	19	100,000	Oral sulphonamide additional to penicillin after 3 days	Cornea perforated; leucoma adherens
21	M	63	Yes	Nil	—	½	Poor	57	12	100,000	Oral sulphonamide and intramuscular penicillin after 3 days	Cornea opaque

TABLE I—*continued.*

(b) Treatment by concentrated Penicillin Ointment.

No.	Sex	Age	History of trauma	Culture	Lesion other than infected ulcer	Hypopyon	Treatment		Response	Days in Hospital	End result
							Concentration used: U/gm.	Frequency of application			
22	M	58	Yes	Staph. albus.	Moderate iritis	¼	100,000	3 hourly	Good	7	Central corneal scar. V.=6/60
23	M	51	No	Not done	Mild iritis	Minimal	100,000	4 hourly	Good	18	V.=6/5
24	M	68	Yes	Staph. aureus	Interstitial infiltration with moderate iritis	½	50,000	Hourly for 2 days	Good at first. Relapse after two days. Rapidly developing panophthalmitis	12	Eye excised
25	M	60	No	Nil	—	—	—	—	—	—	—
						(c) Treatment by Penicillin Drops					
25	M	60	No.	Nil	—	¼	10,000 (oily)	Hourly for 4 days	Poor	26	—
25a	Second admission				—	—	(Relapse 10 days; cleared by two subconjunctival injections)		Good	—	V.=6/12
26	F	65	No	Not done	Mild iritis	¼	2,500	¼; ½; 1 hourly, then 2 hourly	Good	11	Barely perceptible scar. V.=6/9

TABLE I—*continued.*

(d) Treatment by daily "carbolising" the Ulcer with Penicillin 2,500 units c.c. and subsequent application of dilute penicillin ointment (400-800 U/gm.).

No.	Sex	Age	History of trauma	Culture	Lesion other than infected ulcer	Hypopyon	Treatment		Response	Days in hospital	End result
							Concentration of ointment used: U/gm.	Frequency of application of ointment			
27	M	52	No	Nil	—	Minimal	800	Hourly	Good	15	V. = 6/9
28	M	73	Yes	Nil	Moderate iritis	Minimal	800	Hourly	Good	10	Barely perceptible scar. V. = 6/24
29	M	52	Yes	Staph. albus	—	⅛	800	4 hourly	Good	19	Faint nebula. V. = 6/9
30	M	52	Yes	Nil	Mild iritis	Minimal	800	4 hourly	Good	19	Scar. V. = 6/18
31	F	81	Yes	Not done	Severe iritis and interstitial infiltration	⅛	800	4 hourly	Poor; two relapses	27	V. = 6/24
32	F	61	No (Acne rosacea)	Staph. aureus	Mild iritis	⅛	(a) 800 (b) Course of oral sulphonamide	Hourly	Poor Good	19	Scar. V. = 6/18
33	F	60	No (Rheumatoid arthritis)	Not done	Severe iritis	⅛	(a) 1,000 for 5 days followed by (b) One subconjunctival injection, and course of oral sulphonamide	4 hourly	Poor Poor	64	Central corneal scar. V. = 6/36

TABLE I—*continued.*

(e) Combined local Penicillin and general Sulphonamide Therapy.

No.	Sex	Age	History of trauma	Culture	Lesion other than infected ulcer	Hypopyon	Mode of local penicillin therapy	Response	Days in hospital	End result
34	M	13	Yes	Staph. aureus	Severe iritis	1/3	Ung. 25,000 U/gm., 4 hourly, and subconjunctival injections 6 hourly	Good	15	V. = 6/9
35	M	69	No	Not done	Mild iritis	Minimal	12 instillations of gutt. 2,500 U/c.c. at 5 mins. intervals Subsequently Ung. 800 U/gm. hourly	Good	12	V. = 6/9
36	M	58	Yes	Not done	—	½	(a) 27 subconjunctival 6 hourly. (b) T.A.B. subsequently	Poor Fair	39	Moderate central opacity. V. = 6/18
37	M	22	Yes	Staph. aureus	Moderate iritis; interstitial infiltration	Minimal	(a) "Carbolizing" with penicillin 2,500 U/c.c. and Ung. 800 U/gm. hourly. (b) T.A.B. subsequently	Poor —	34	V = 6/60

(f) Exclusive General Sulphonamide Therapy.

No.	Sex	Age	History of trauma	Culture	Lesion other than infected ulcer	Hypopyon	Treatment	Response	Days in hospital	End result
38	M	33	Yes	Not done	Moderate iritis	½	Sulphamezathine	Good	7	V. = 6/9
39	F	61	No	Not done	Iritis; corneal abscess on 12th day	½	(a) Sulphamezathine followed by (b) Ung. Penicillin 800 U/gm. hourly	Poor Poor	58	V. = H.M.

					12th day		(b) Ung. Penicillin 800 U/gm. hourly	Poor			

TABLE II.

Neuropathic or herpetic keratitis with hypopyon.

No.	Sex	Age	History	Lesion	Hypopyon	Culture	Response	Days in hospital	Treatment (apart from atropine)	End result
40	M	64	Herpes ophthalmicus 2 years before	Infected ulcer. Mild iritis	Minimal	—	Poor	35	(1) For 3 days daily "carbolization" with penicillin 2,500 U/c.c.; ung. penicillin 800 U/gm. hourly and methyl salicylate cauterizing Then (2) Oral sulphamezathine and Ung Albucid.	Enucleation
41	M	82	Herpes ophthalmicus	Infected ulcer and mild iritis	1/3	Staph. aureus.	Poor	59	Oral sulphamezathine (for 4 days) together with ung. penicillin 800 U/gm. 2 hourly, and methyl salicylate cauterizing daily.	Descemetocele on 14th day. Total corneal opacity. V = P.L.
42	F	84	Herpes ophthalmicus Spastic entropion	No corneal lesion. Severe iritis	¼	—	Fair	34	Operation on entropion, and instillation of ung. penicillin 50,000 U/gm. 3 hourly. Also subconjunctival penicillin 50,000 units 3 in the first week and 2 each in the second and third weeks.	V = 6/18 p.
43	M	34	Alcohol injection of Gasserian ganglion for tic douloureux	Infected ulcer and mild iritis	Minimal	Nil.	Good, but relapse 12 days later	26	(1) Three subconjunctival penicillin injections 50,000 units 6 hourly followed by ung. penicillin 100,000 units 4 hourly. (2) Seven more injections on relapse, followed by tarsorraphy.	Dense leucoma

TABLE II.—*continued.*

No.	Sex	Age	History	Lesion	Hypopyon	Culture	Response	Days in hospital	Treatment (apart from atropine)	End result
44	M	46	Recurrent dendritic ulcer. 4 or 5 attacks	Infected ulcer. Mild iritis	½	—	Poor	16	(1) Subconjunctival penicillin 50,000 units 4 hourly and ung. penicillin 100,000 U/gm. 4 hourly for 2 days. Then (2) Oral sulphamezathine 30 gms.	Dense leucoma V = 2/60
45	M	76	4 months — persistent superficial punctate staining. Cornea anaesthetic	Infected ulcer. Mild iritis	½	—	Good	9	12 subconjunctival injections of penicillin 50,000 units 6 hourly.	V = P.L.
46	M	49	5 years — intermittent dendritic corneal ulceration. 3 weeks — recurrence	Infected ulcer	Minimal	Nil.	Poor	51	In succession: (1) 12 subconjunctival injections and penicillin 50,000 U/c.c. 6 hourly, and ung. penicillin 100,000 U/gm. 4 hourly. (2) Oral sulphamezathine 30 gms. (3) Milk injections. (4) Short wave therapy.	Dense leucoma
47	F	61	10 months previously a dendritic ulcer. Started as iritis and developed corneal stain on 24th day of treatment	Interstitial infiltration. Moderate iritis	Minimal	—	Poor	35	(1) Ung. penicillin 400 U/gm. 4 hourly for 6 days. Then (2) Sulphamezathine 30 gms.	Spontaneous improvement after cessation of all treatment

TABLE II.—*continued.*

No.	Sex	Age	History	Lesion	Hypopyon	Culture	Response	Days in hospital	Treatment (apart from atropine)	End result
48	M	19	Gradual onset over 3 weeks. Poor sensation	Interstitial infiltration resembling disciform keratitis. Moderate iritis	Minimal	—	Poor	25	(1) 20 subconjunctival injections of penicillin and ung. penicillin 100,000 U/gm. 4 hourly. (2) Tarsorraphy.	Relapse. V = 6/36. Under treatment
49	M	57	One week gradual onset of pain in eye. Cornea insensitive	Infected corneal ulcer and severe iritis	1/3	Nil.	Poor	46	20 subconjunctival injections of penicillin 6 hourly, and ung. penicillin 100,000 U/gm, 4 hourly.	Total corneal opacity. Iris bound down. V = P.L.
50	M	60	Similar attack 10 years ago. Cornea insensitive. Sore 3 weeks	Infected ulcer and severe iritis	1/3	—	Poor	54	Ung. penicillin 800 U/gm. hourly and drops 2,500 U/c.c. at 15 minutes—1 hour for 8 days. Subsequently oral sulphamezathine.	Dense leucoma
51	F	60	Tarsorraphy in the past. Broken down corneal scar; 3 days later hypopyon ulcer. Cornea insensitive	Interstitial infiltration and moderate iritis	1/3	Nil.	Poor	24	Ten subconjunctival injections of penicillin, and ung. penicillin 100,000 U/gm. 4 hourly. Subsequently repeated. A.C. wash out and milk injections.	Dense leucoma

TABLE III.

Glaucomatous eyes associated with hypopyon.

No.	Sex	Age	History	Culture	Lesion	Hypopyon	Response	Days in hospital	Treatment	End result
51	F	85	For 5 years a blind glaucomatous eye	—	Large corneal abscess	½	Poor	18	(1) Penicillin drops 2,500 U/c.c. ½ hourly for 6 hours followed by ung. penicillin 800 U/gm. 4 hourly for 5 days. Albucid drops subsequently for 4 days	Enucleation on 9th day
52	M	62	Old iritis, secondary glaucoma	—	Iris bombé	¼	Poor	32	Twelve subconjunctival injections of penicillin followed by 2 intravitreal injections 5,000 units penicillin and oral sulphamezathine	Evisceration
53	M	41	Bilateral buphthalmos c. iridectomy at age of 10. Eye hit with twig 5 days ago	Staph. aureus at evisceration	Infected corneal ulcer	¼	Poor	48	(1) 44 subconjunctival injections together with ung. penicillin 100,000 units 2 hourly. (2) On 4th and 6th days intravitreal injection of penicillin 5,000 units with sulphapyridine from 4th day onwards. Paracentesis on 6th day.	Evisceration. Hypopyon had disappeared after 24 hours but panophthalmitis rapidly developed
54	F	64	A blind eye due to chronic glaucoma	Pneumococci	Infected ulcer and moderate iritis	¼	Good	37	Two subconjunctival injections penicillin 50,000 units. Ung. penicillin 8,000 U/gm. hourly	Corneal nebula
55	F	74	Blind eye from long standing chronic glaucoma	Nil.	Infected ulcer and mild iritis	¼	Good	19	(1) "Carbolization" with penicillin 2,500 U/c.c. and ung. penicillin 800 U/gm. hourly for 3 days. Then (2) oral sulphamezathine	Corneal nebula

TABLE IV—*Hypopyon Iritis*

No.	Sex	Age	History	Lesion other than iritis	Hypopyon	Response	Days in hospital	Treatment (apart from atropine)	End result
57	F	40	Recurrent bilateral iritis. Congenital spastic paraplegia	Interstitial infiltration right cornea	1/3	Poor	40	In succession:—(1) Subconjunctival penicillin 50,000 units 6 hourly, and Uug. penicillin 25,000 U/gm. 4 hourly for two days. (2) Oral sulphamezathine. (3) Short wave therapy	R.V.=P.L. L.V.=6/60
58	F	82	Influenza 14 days before admission. Old rheumatoid arthritis	—	¼	Good	15	(1) Two subconjunctival injections of penicillin 50,000 units; followed by oily penicillin 10,000 U/c.c. 2 hourly	Cornea clear. Atrophic iris. V.=H.M. Lens opaque
59	F	27	Recurrent bilateral iritis	—	Right minimal. Left ¼	Good	21	Subconjunctival penicillin 50,000 units 4 hourly for 4 days	R.V =5/60 L.V.=C.F. at 1m.
59a	Second admission		ditto	—	Right minimal	Good	6	As before	—
60	F	63	Diabetic iritis, rubeosis and secondary glaucoma	Infected corneal ulcer	¼	Good	22	(1) Subconjunctival penicillin 50,000 units 6 hourly, and ung. penicillin 100,000 U/gm. 4 hourly for 3 days, followed by (2) Oral sulphamezathine and short wave therapy	—
60a			ditto	ditto	¼	Good	26	(1) Subconjunctival penicillin 50,000 units 6 hourly, and ung. penicillin 100,000 units 4 hourly for 3 days followed by (2) Short wave therapy	Dense corneal scar. Occluded pupil

TABLE IV—*Hypopyon Iritis*—(*continued*).

No.	Sex	Age	History	Lesion other than iritis	Hypopyon	Response	Days in hospital	Treatment (apart from atropine)	End result
61	M	26	Acute iritis	—	Minimal	Good	18	Ung. penicillin 8,000 U/gm. 4 hourly and oral sulphamezathine simultaneously	Eye normal. V. 6/6
62	M	8	Endophthalmitis following an infectious illness a year ago. Blow on eye 4 days ago	Endophthalmitis	Minimal	Good	43	(1) Two subconjunctival injections of penicillin 50,000 units; also ung. penicillin 25,000 U/gm. 2 hourly, with oral sulphamezathine simultaneously	Shrunken eye
63	F	31	Acute iritis	—	Minimal	Good	8	Oral sulphamezathine	Eye normal. V. 6/6
64	M	61	Recurrent iritis	—	Minimal	Good	10	Sulphamezathine 30 gms., mydricaine and short wave therapy	V.=6/18
65	M	25	Acute iritis	—	¼	Good	19	Heat	Eye normal. V. 6/6
66	M	57	Left iritis 5 years ago. Recurrence now with hypopyon	—	¼	Good	0	Mydricaine daily	Hypopyon disappeared within 3 days. V. 6/24

Discussion

1. *Causes of hypopyon formation.*—Hypopyon as a complication of infected corneal ulcer, and hypopyon associated with iritis are clearly recognised as distinct clinical entities. The fundamental difference is, of course, that in the first group the cornea is the seat of the primary lesion, and in the second the iris lesion is the responsible factor. This distinction is important and generally valid, but the presence of a corneal lesion in two of the cases of hypopyon iritis (Nos. 57 and 60) shows how difficult it may be in individual cases to assess the type of hypopyon with which one is dealing—a difficulty all the more real as severe iritis is not infrequent in hypopyon corneal ulcers. The diagnostic difficulties are complicated still further by the occurrence of hypopyon in the group of cases shown in Table II. Both iritis and corneal ulcer were present in most of these cases, which, however, constitute a distinct entity of their own in that the primary lesion appeared to be neither of these affections, but loss of corneal sensation of a trophic or possibly virus origin. This group does not appear to be well recognised, but the therapeutic response no less than the disturbed corneal sensation leave no doubt that it must be regarded as distinct from the others. In a final group, glaucomatous degeneration of the eye appeared to have been the primary disturbance, with the hypopyon formation as the result of either an iris reaction or a corneal lesion.

As distinct from these four types, there were cases of hypopyon formation following an operation, or on infection carried into the eye by trauma. These cases have not been considered in the present study because their fulminating course and response to treatment would suggest that they are true infections as distinct from aseptic inflammatory reactions and require detailed consideration on their own.

2. *Response to treatment.*—It is clear from the data in Tables I-IV that generally speaking infected corneal ulcers (as tabulated in Table I) respond well to local penicillin therapy, and that hypopyon formation secondary to herpetic or neuropathic corneal lesions gives no response. It would also seem that whether a response is obtained in hypopyon formation in glaucomatous eyes depends upon the condition of the eye, and possibly also whether the hypopyon is septic in origin. In contrast to the efficacy of penicillin in infected corneal ulcers, and its uselessness in the herpetic and neuropathic hypopyon formation, is the lack of need of penicillin in hypopyon iritis. From the data shown in Table IV it is seen that hypopyon iritis responds well to treatment by atropine, and nothing else is required.

Reduced to general terms one may perhaps say that an infected

corneal ulcer is sterilised by the action of penicillin; this explains the value of penicillin in these cases—the hypopyon disappears when the primary infection is brought under control. In contrast, hypopyon formation secondary to virus or neuropathic corneal lesion does not respond to penicillin, presumably because the virus is penicillin-resistant, and that in a neuropathic lesion there may be no infecting agent at all. Finally in hypopyon iritis control of the inflammatory iris reaction by atropine brings about absorption of the hypopyon; penicillin is unnecessary as there is no bacterial exciting factor. As in infective lesions generally, so in hypopyon reactions, penicillin can give results only when the exciting cause is infective in character and susceptible to penicillin.

3. *Mode of use of penicillin: theoretical considerations.*—It has been shown elsewhere (Sorsby and Ungar, 1946) that subconjunctival injection of 25,000 units of penicillin gives higher and more sustained aqueous levels than the administration of 50,000 units intravenously, or 40,000 units in beeswax intramuscularly, or of the insertion into the conjunctival sac of ointment containing 100,000 units per gm. The simpler procedures of the instillation of drops, and of ointments containing a low concentration of penicillin are inapplicable if an adequate intra-ocular level of concentration is to be reached (Struble and Bellows, 1944). Nothing is known of the concentration in the aqueous on the application of penicillin in solid form to the surface of an infected corneal ulcer as advocated by Juler and Young.

On theoretical grounds it would therefore seem that subconjunctival injection is the method of choice for obtaining and maintaining high intra-ocular levels of concentration of penicillin. It is superior to both systemic administration and to other methods of local application. The detailed studies of Andrews (1947) and of Sorsby and Ungar (1947) have confirmed the high intra-ocular levels of concentration reached by this mode of administration of penicillin. It would furthermore appear that the addition of adrenalin to the penicillin materially increases both the levels reached and the levels maintained, as can be seen from the following summary table (Sorsby and Ungar, 1947).

Level of penicillin in the aqueous and the cornea of the rabbit after subconjunctival injection of 50,000 units pure penicillin with and without adrenalin

Hours	¼	½	1	2	3	4	6
Aqueous: Without adrenalin	24	19	17	9	3	0·75	0·56
Aqueous: With adrenalin ...	>32	>17	>32	>32	>20	20	1·25
Cornea; Without adrenalin	950	97	76	25	18·75	4.87	1·5
Cornea: With adrenalin ...	>860	>200	>1,440	925	450	65	2·5

The clinical use of massive doses of penicillin subconjunctivally only became possible with the advent of purified penicillin. With such penicillin, injections of 50,000 units are well tolerated, even when repeated frequently. (Sorsby and Ungar, 1946.)

4. *Management of hypopyon corneal ulcer susceptible to penicillin.*—Theoretical expectations are borne out by the results recorded for the cases summarized in Table I. Subconjunctival injection of penicillin proved superior to several other modes of applying penicillin. The relative value of subconjunctival penicillin and oral sulphonamide cannot be assessed, as no substantial studies on the effect of the sulphonamides on hypopyon keratitis appear to be available.

As this work was progressing a standard method of treatment began to emerge. At the moment the routine used consists of the following steps:

(1) After a smear is taken for culture purposes the eye is irrigated with half normal saline at room temperature to remove any organic matter.

(2) The conjunctiva is anaesthetised by the instillation of two drops of 4 per cent. or 5 per cent. cocaine hydrochloride solution, repeated if necessary.

(3) Into an ampoule containing 100,000 units of white crystalline penicillin 0·5 c.c. of 2 per cent. novocaine and 0·5 c.c. of adrenalin 1 :1,000 is injected. 0·5 c.c. is now withdrawn and injected subconjunctivally.

(4) Drops of atropine are instilled into the conjunctival sac and the eye is bandaged.

(5) Injections are repeated at 6-hourly intervals for three days, so that a total of 12 injections are given in all cases. Where response appears to be halting another four injections are given over an additional day.

(6) When injections are suspended penicillin ointment in a concentration of 100,000 units per gm. is instilled at four-hourly intervals day and night. The ointment should be made up with a specially prepared base of petroleum jelly and liquid paraffin 90 and 10 parts of each respectively. The penicillin is incorporated into this base without dissolving it in water. The ointment is continued for 48 hours after apparent clinical cure.

Whilst normally the solvent for the penicillin injected subconjunctivally is an equal quantity of 1 :1,000 adrenalin and of 2 per cent. novocaine, it is possible to use either solvent by itself. Novocaine helps to overcome the discomfort some patients experience on repeated subconjunctival injections; adrenalin is

well tolerated by most patients. Sterile water can be used, but saline should not be employed as it produces a hypertonic solution which is distinctly uncomfortable on injection. It is feasible to replace either of these solvents by mydricaine where the iritis is particularly intense. Adrenalin solution, because of its low pH, tends to destroy penicillin in vitro (Cameron, 1945). Clinically this deleterious effect does not seem to be substantial; in the tissues subconjunctivally the adrenalin is apparently rapidly buffered; in solution in vitro the amount of penicillin destroyed would appear to be small.

Where no substantial response is obtained with subconjunctival injections at the end of 48 hours, further treatment on these lines is useless.

Subconjunctival injections of penicillin as a method of treating hypopyon formation secondary to infected corneal ulcer give gratifying results. The management of the occasional resistant case is still a problem of some difficulty. A full exploration of the possibilities of oral sulphonamide would seem to be desirable.

Summary

1. Results of treatment, mainly with penicillin, are recorded for 66 patients with hypopyon.

2. This series included 39 cases of infected corneal ulcer; 18 of these were treated by subconjunctival injections of penicillin in doses of 50,000 units with or without the application of penicillin ointment in concentrations of 25,000 to 100,000 units per gm. Other methods of local penicillin therapy were employed in 12 patients. Oral sulphonamide treatment was used in two cases and local penicillin therapy combined with general sulphonamide therapy in four more. In three patients general sulphonamide therapy was used when subconjunctival injections of penicillin proved inadequate.

Twelve patients with hypopyon formation associated with herpetic or neuropathic corneal lesions were treated by various applications of penicillin locally, with or without general sulphonamide therapy.

There were also five cases of old-standing glaucoma showing hypopyon as a complication.

A final group of 10 patients presented 13 instances of hypopyon iritis.

3. Infected corneal ulcers responded well to treatment. Hypopyon seen in herpetic or neuropathic keratitis gave no response. Hypopyon iritis appeared to require no treatment other than atropine.

4. A detailed analysis of the cases of infected corneal ulcers with hypopyon treated by different methods of penicillin therapy shows subconjunctival injections to be the method of choice. It was successful in 18 out of 21 cases so treated.

5. The mode of treatment is described. It consists essentially of 12 to 16 subconjunctival injections each of 50,000 units of penicillin (dissolved in 0·25 c.c. of 2 per cent. novocaine and 0·25 c.c. of 1 :1,000 adrenalin) at intervals of six hours, followed by the 4-hourly instillation of penicillin ointment in a concentration of 100,000 units per gm.

Our thanks are due to Mr. Savin, Mr. Rycroft, Mr. Tyrrell, Miss Dollar and Mr. Cameron of the Royal Eye Hospital for help with clinical material. We are indebted to successive House Surgeons for their help, and to Sisters Bradley and Haffield of the Royal Eye Hospital, and Sisters Hollands and Thorogood of the Lambeth (L.C.C.) Hospital Ophthalmic Unit for their loyal and painstaking collaboration.

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THE LAMINA CRIBROSA AND ITS NATURE*

BY

Professor MARIAN WILCZEK

CRACOW

THE present knowledge of this subject is based mostly on the work of E. Fuchs (1916) as there have been no newer researches in this field. The cribriform lamina is generally taken to be a semi-independent structure. The dimensions of its anterior and posterior planes, its thickness and backward curve and other dimensions have been already measured. In cases of glaucoma the possibility of the cribriform lamina being pushed backward by the raised intra-ocular pressure has been generally accepted.

Birnbacher and Czermak (1885—1886) have likened the cribriform lamina to a membrane of India-rubber which can bulge under

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intra-ocular pressure. According to the generally accepted opinions the cribriform lamina is a part of the sclera. Lauber in his textbook, published in 1936, writes: " The internal layers of the sclera form in the scleral canal a network of lamina cribrosa sclerae; strictly speaking it is only the thinned part of the sclera." E. Fuchs states: " Part of the fibres of most internal layers of the sclera is stretched over the foramen sclerae . . . . this part when cut looks like a sieve, and therefore it is called lamina cribrosa."

The opinions of other authors are almost similar. These views are not necessarily strictly accurate. For instance, in a case of deep physiological depression of the optic disc one sees through the ophthalmoscope the cribriform lamina lying 1—1·5 mm. below the level of the retina. Now it is known that the sclera in this region is 1—1·5 mm. thick. Round the optic nerve it becomes thinned to one-half or one-third by the inter-meningeal recess (recessus intravaginalis). So it can hardly be maintained that the cribriform lamina is really a thinned part of the sclera. In this case at least posterior trabeculae of the cribriform lamina must be derived from the pia mater of the optic nerve and not from the sclera.

Rather complicated relations in the arrangement of neuroglia in the optic disc, in the first segment of the optic nerve and in the insertions of meningeal sheaths of the nerve to the sclera can be understood only in view of certain facts derived from the development of the eye. The publications of Seefelder (1910), Kleczkowski (1913) and v. Szily (1921—1922, 1930) have the greatest bearing on this subject. All changes leading to the conversion of the optic vesicle into the optic cup aim at creating the best connections of nerve-fibres of the retina with the brain by forming the embryonic disc of the optic nerve (papilla primitiva s. epithelialis). Nerve-fibres of the retina grow into this embryonic disc, and so there develops the definite optic disc, collecting into a bundle all nerve-fibres of the retina. Cells of the stalk of the cup convert into neuroglial cells, and so neuroglial stroma of the optic disc and nerve are developed. Bundles of nerve-fibres are separated one from another by neuroglial tissue which forms the first septa of the optic disc and nerve. Only later—as Kleczkowski has shown—connective cells grow into these neuroglial septa, and supply the nerve with vessels. Connective tissue divides the nerve into smaller and smaller bundles forming first-, second- and third-grade septa; but still smaller septa are formed by neuroglia.

Bearing this in mind, one may understand the relations between neuroglial and connective tissue. Neuroglia completes connective septa and carries on the partition into still smaller bundles, forms a sheath between the walls of the scleral canal and the disc (intermediäres Gewebe), invests anteriorly central connective tissue

which envelops the vessels (Zentr. Bindegewebsmeniskus Kuhnt), penetrates into the disc along the vessels (Schaltgewebe), forms the so called neuroglial cribriform plate (lamina gliosa), and envelops each connective septum in the cribriform lamina and in the nerve. All these details in distribution of neuroglia are fairly clear, if one remembers that the stalk into which nerve-fibres have eventually grown, was of neuroglial origin, and that connective tissue has grown into primitive neuroglial septa, rather strengthening them than eliminating them completely.

All connective coats of the eye, such as the choroid, the sclera, meningeal sheaths of the optic nerve, septa of the optic nerve and the cribriform lamina are formed from the same mesenchymal mass, which envelops the embryonic eye when the retina, the optic disc and nerve have already been formed. That is why there is no sharp division between pia or dura mater and the sclera, but meningeal sheaths pass into and coalesce with the sclera.

In order to be thoroughly acquainted with the structure of the cribriform lamina, its relation to the sclera and septa of the optic nerve, with its function and importance, I have carried out a series of my own investigations. I have studied histological longitudinal and transverse sections of the cribriform lamina, not only of adults but also of the newly-born and embryos. I have also studied the structure of the cribriform lamina of the following animals: cat, pig, horse, and ape. The examination of the complete series of transverse sections seems to me most instructive.

When examining the preparations from different periods of the development of the eye, I could demonstrate that the cribriform lamina develops comparatively late, and its complete development is attained as late as the end of foetal life or even at the beginning of extra-uterine life. Trabeculae of connective tissue grow into the nerve and the disc from all directions and from all available sources of connective tissue, namely from the pia mater, from the sclera in the scleral canal and—as can be demonstrated in the series of transverse sections — also from connective tissue, which accompanies the central vessels. These connective trabeculae form the septal network of the nerve. By their ingrowth the nerve is supplied with vessels and its structure strengthened, delicate nervous tissue connected with the pia mater and the optic nerve inside the scleral canal fixed to the sclera.

In the embryonic eyes, where there is as yet no cribriform lamina and no connective septa of the nerve, it can sometimes be observed how the optic nerve slips out of the scleral canal (Fig. 1). Trabeculae which grow into the nerve from all sources of connective tissue in this region must be stronger, the more abundant the source of connective tissue. In that way one should explain the

FIG. 1.

The optic nerve in a human embryo, 6 months old, which has not been attached to the scleral canal by the cribriform lamina, and has slipped out of the canal.

fact that trabeculae in the cribriform lamina are much thicker than in the nerve, for septa of the nerve come from the comparatively thin pia mater, whereas trabeculae of the cribriform lamina come from abundant connective tissue of the sclera. Sometimes one can notice delicate trabeculae penetrating into the optic nerve from the choroid; they are called by the authors: lamina cribrosa choroidealis. These trabeculae are rather scanty and thin, which can be explained by the fact that the choroid is rather a poor source of connective tissue. I consider fixation of the optic nerve in the scleral canal, *i.e.*, in the place where the optic nerve is exposed to the great danger of being pulled, as one of the most important functions of the cribriform lamina.

During my studies of the cribriform lamina I have made the first plastic model of this region of the eye which enables one to visualize the relations in three dimensions. This model has been constructed in the following way: from a complete series of histological sections of the optic nerve of a normal human eye—sections being 20 microns thick—I chose the sections comprising the whole scleral canal from the anterior plane of the sclera to the first segment of the optic nerve surrounded by the intermeningeal space. I took microphotographs of each section and magnified them 50 times on paper, under which I inserted a layer of mixture of paraffin and beeswax, 1 mm. thick. Thereby I obtained a series of plates, each corresponding to a microscopic section,

magnified 50 times. From these plates, using Graefe's knife and Gullstrand's binocular, I excised all the outlines of nerve-bundles, leaving only septal network of connective tissue. In this way I obtained the isolated connective scaffolding of the nerve surrounded by the sclera or pia mater. By sticking all the plates together I obtained a model which enabled me to study carefully all the details. While looking at the transverse sections of my series and putting the model together I became convinced that there is no substantial difference between the cribriform lamina and the septal system of connective tissue of the optic nerve. They actually form one common system whose parts can be differentiated only by their point of origin. In the scleral canal, trabeculae are thicker because they come from the sclera; in the nerve they are thinner because they come from pia mater.

The cribriform lamina is then not an independent structure but the foremost and strongest part of the septal system of connective tissue of the nerve.

Fig. 2 shows a section, 89, of my series. One can see in the upper part the septal network coming from the wall of the scleral canal; it is the cribriform lamina. In the lower part of this preparation, trabeculae must come from pia mater as the intermeningeal space can be clearly seen. These trabeculae belong to the septal system of the nerve. There is no difference between these two systems. They both form a uniform network whose trabeculae are

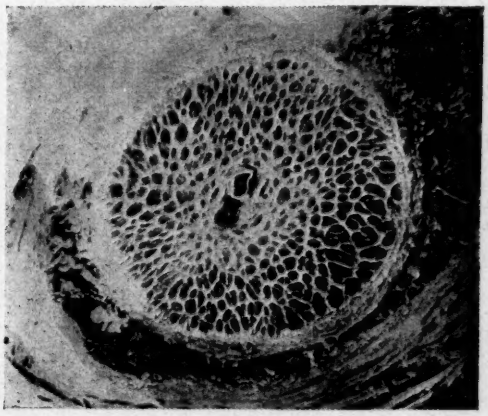

FIG. 2.

In the upper part of the preparation notice a trabecular network of the cribriform lamina coming from the sclera, in the lower part the septal network of the optic nerve coming from pia mater.

a little thicker in the part which has to be included in the cribriform lamina. On the whole one can compare this septal system to the canals of connective tissue in whose walls there are numerous gaps. The canals may join the neighbouring one or divide.

Fig. 3 represents the front view of the model. In the foremost part of the scleral canal there is an apparent shallow depression, at the bottom of which one may see the front of a septal system, i.e., the cribriform lamina. This depression, demonstrated for the first

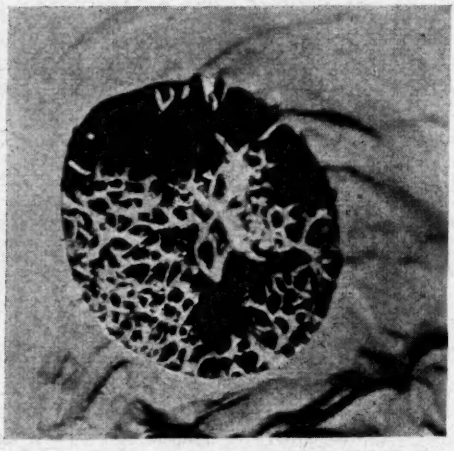

FIG. 3.

The plastic model viewed from the front. Notice the depression called by the author "the nest of the optic disc."

time on my model, should be called the nest of the optic disc (nidus seu nidulus papillae nervi optici), because in this very depression lies the optic disc. The bottom of the nest is uneven, slightly knob-like. Trabeculae of the cribriform lamina lie there but not on the same level, some being a little higher than the others. Moreover some trabeculae come from the walls of the nest, sometimes even from the anterior surface of the sclera. From the bottom of the nest there arises towards the front a fairly thick bundle of connective tissue investing the central vessels. In the disc short trabeculae come from this bundle and join the tissues of the disc. As the diameter of the nerve increases with its further course, the lateral walls of the nest are inclined and divergent. The shape of the nest may change according to the shape of the optic disc. All the dimensions of the nest and the inclination of its walls can vary to a certain extent.

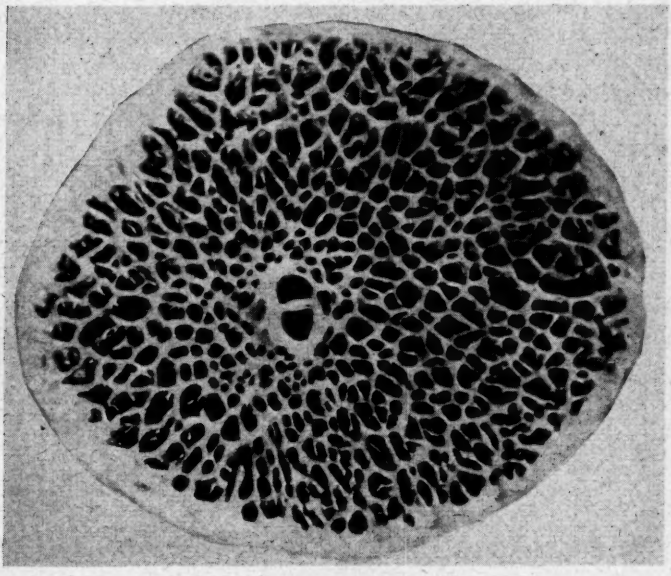

FIG. 4.

The model viewed from behind. Septal system of the optic nerve.

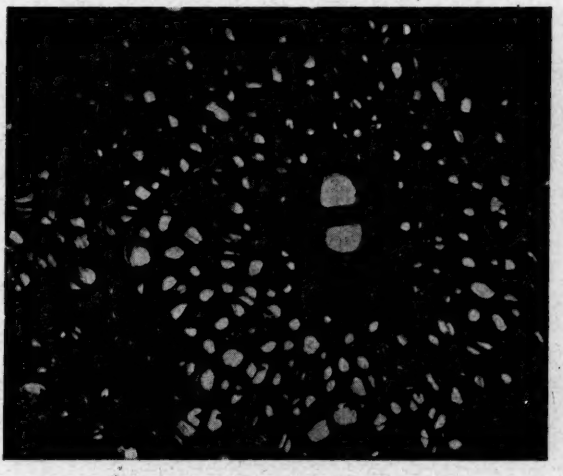

FIG. 5.

The model transilluminated from behind.

In my opinion introduction of the concept of the nest of the optic disc is advisable as much from the anatomical as the clinical point of view. This concept will permit more synthetic representation of the shape of the foremost part of the scleral canal.

Fig. 4 represents the septal system of the optic nerve viewed from behind in my model. Fig 5 part of the model illuminated from behind. One can see the interior of the canals in which there were bundles of nerve-fibres. Figs. 6 and 7 represent the model cut in the sagittal plane. One can see for the first time the outlines of septa at the same time in transverse and longitudinal sections.

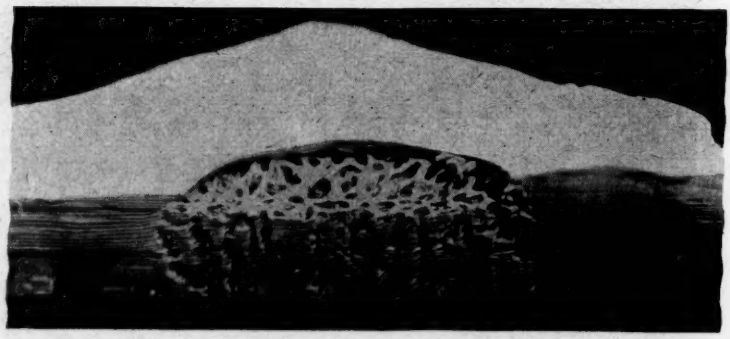

FIG. 6

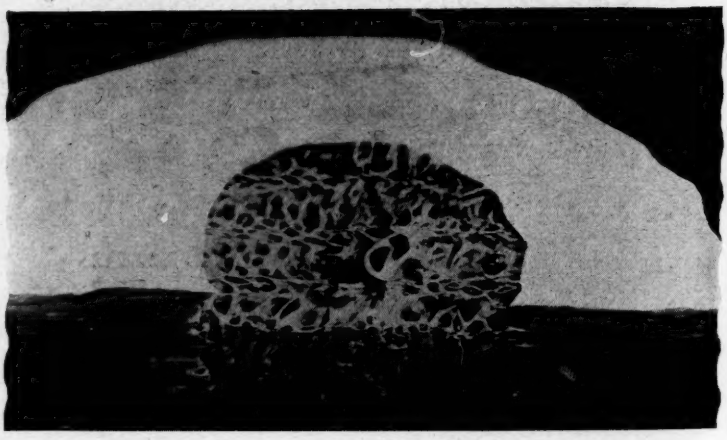

FIG. 7.

The relations between nervous and connective tissue are changing at various levels of the optic disc and nerve. In the disc there is almost complete lack of connective tissue. Beyond the cribriform lamina septa become thinner whereas bundles of nerve-fibres, developing myelin sheaths, become thicker. In order to determine strictly these relations I took the following measurements: from the microphotographs of the sections, magnified 50 times, I cut out with Graefe's knife the outlines of nerve bundles—as I did when making the model—leaving only the network of connective tissue. Then I cut out the neighbouring scleral tissue, the meninges and the outlines of the vessels. So, using the balance, I could strictly determine the relation between connective and nervous tissue in a given section. Then I calculated the area of the section, and knowing the percentage relation of the tissues and the magnification, I could easily calculate the real area occupied by each tissue in a given section. As I knew the number of holes, occupied by nerve-bundles in each section, I could calculate the average size of a nerve-bundle and the thickness of a septum of connective tissue. For my calculations I chose the sections at different levels of the disc, the cribriform lamina and the optic nerve. These are the sections of my series labelled 61, 65, 75, 79 and 95. Section 61 passes through the first part of the scleral canal in which there are no septa of connective tissue yet and nervous tissue still retains the structure of the disc. In the periphery of the section 65 there are already some short trabeculae of septa. Section 75 passes through the anterior part of the cribriform lamina, section 79 through the strongest part of the cribriform lamina, section 95 through the first part of the optic nerve, surrounded by the intermeningeal space. The results of these calculations are shewn on the Table I:—

Section	Area of section	Area of nervous tissue	Area of connective tissue	Nervous tissue in per cent.	Conn. tissue in per cent.	Amount of nerve bundles
				per cent.	per cent.	
61	1·35mm.²	1·28mm.²	—	ca.95	—	—
65	1·60 „	1·28 „	—	ca.80	ca.20	—
75	2·44 „	1·09 „	1·35mm.²	44·7	55·3	350
79	2·50 „	0·9 „	1·60 „	36	64	394
95	3·10 „	1·78 „	1·32 „	57·4	42·6	398

It follows from this table that the area of section of the optic disc is 2·3 times smaller than the area of section of the first part of the optic nerve situated only 0·7 mm. below the former (sections 61 and 95). In the disc, 95—80 per cent. of the section is occupied by nervous tissue, compared with 36 per cent. in the most strongly developed part of the cribriform lamina where the remaining area is occupied by connective tissue. The figures of Table I can represent a real basis for any inferences concerning endurance of this area to endocular pressure, to stretching and to mechanical distortions, which occur in inflammatory processes, oedema, etc. From column 2 one can see that nervous tissue in the disc occupies greater area than in the cribriform lamina. As the amount of nerve-fibres is the same in both cases it follows that nerve-fibres in the disc lie more loosely, embedded in soft neuroglia. In the anterior layer of the cribriform lamina (section 75) the area of nervous tissue is a little greater than in the strongest part of the cribriform lamina (section 79) where nerve-fibres lie most tightly. Here, and not in the anterior opening of the scleral canal nor in the opening of lamina elastica choroidealis—as could be inferred from the longitudinal histological sections—there is the narrowest passage for nerve-fibres.

That is in the cribriform lamina that nerve-fibres can be most easily damaged by inflammatory processes, oedema, hyperaemia of trabeculae of connective tissue, etc.

Fig. 8 represents these relations in their true proportions, according to the calculations in Table I. The whole mass of nervous tissue lies in the centre of the drawing; it has the shape of an hour-glass. On each side there is a mass of connective tissue which varies in strength in different sections. In column 3 of Table I, section 75 contains nearly the same amount of connective tissue as section 95 which corresponds to the first segment of the optic nerve. It can be inferred that septa in the first segment of the

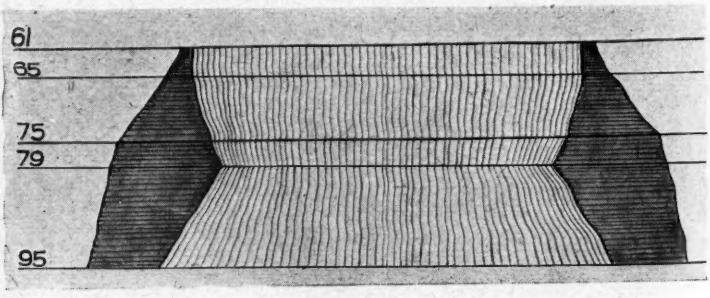

FIG. 8.

optic nerve are thinner than these in the first segment of the cribriform lamina not as a result of the smaller amount of connective tissue in the first segment of the nerve, but because these septa have been stretched by the bundles of nerve-fibres becoming thicker under the influence of myelinisation. The amount of connective tissue in the strongest part of the cribriform lamina is only 18·5 per cent. greater than in the anterior part of the cribriform lamina.

If one knows the area of connective and nervous tissue in the section and the amount of nerve-bundles one can calculate as well the average area and the diameter of a single nerve-bundle as the thickness of surrounding connective tissue. I calculated it for sections 79 and 95 (strongest part of the cribriform lamina and first segment of the nerve). The results are given on Table II:—

Section	Area of one nerve-bundle	Diameter of one nerve-bundle	Area of one nerve-bundle together with connective tissue surrounding it	Difference of diameter i.e., thickness of the sheath of connective tissue between nerve-bundles
79	0·00225mm^2	0·0534mm	0·00625mm.^{2}	0·0346 mm.
95	0·00445 „	0·075 „	0·00775 „	0·024 „

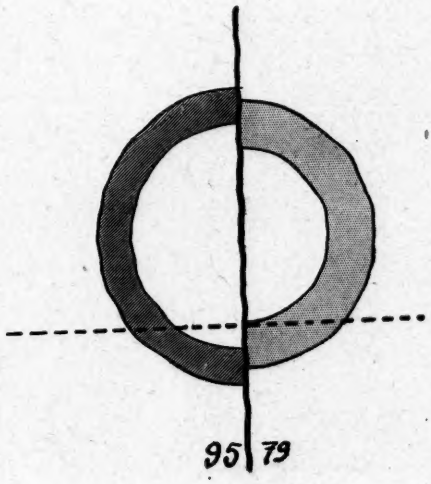

FIG. 9.

Fig. 9 represents the transverse sections 79 and 95, compared one with another. The dotted line shows how the longitudinal section of the optic nerve could cut only a septum of connective tissue in the cribriform lamina, and at the same time a nerve-bundle in the optic nerve. Fig. 10 represents it in a plastic way. Let us imagine the sections 79 and 95, made from a transparent material and lying one on another. The longitudinal section of the optic

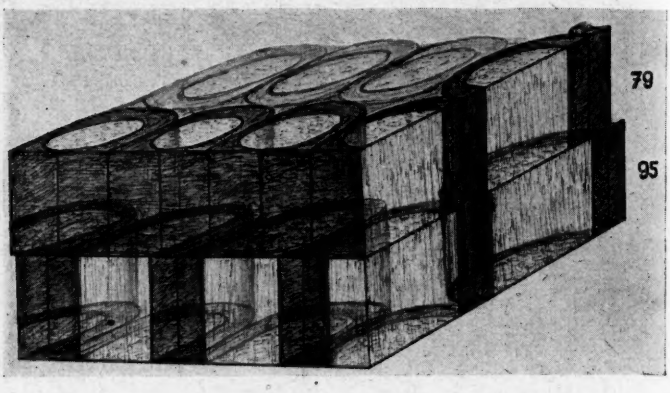

FIG. 10.

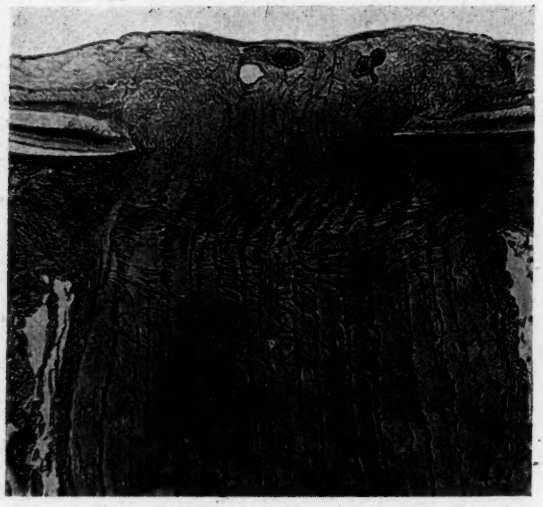

FIG. 11.

nerve passing the cribriform lamina would cut a septum of connective tissue, but passing the nerve itself would cut a nerve-bundle.

That is how " typical " histological pictures of the cribriform lamina can be explained. These pictures depend on the plane of the section. One can see diagrammatically in Fig. 9 that it is not

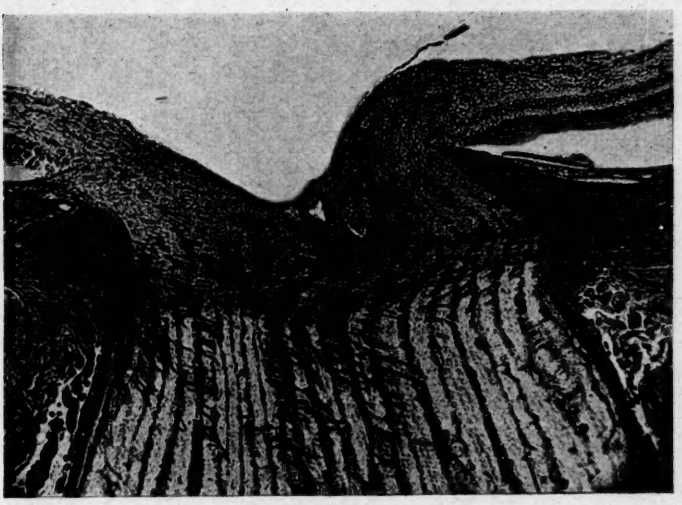

FIG. 12.

FIG. 13.

the greater thickness of septa of connective tissue in the cribriform lamina, but the greater diameter of myelinised nerve-fibres in the optic nerve that plays here a rôle. In Fig. 10 one may see the possibility of another cut which would pass nerve-bundles as well in the cribriform lamina as in the optic nerve. In such a case, in histological sections the pictures of the cribriform lamina would not be so typical. It is clear that in the same optic nerve one may obtain some pictures of strongly, and some of weakly, developed

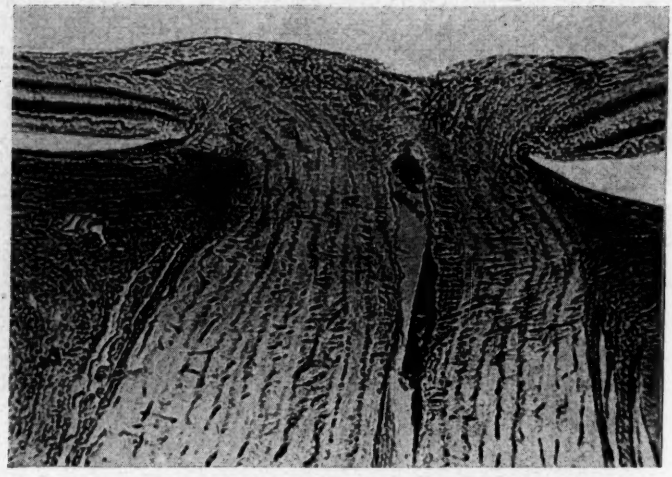

FIG. 14.

cribriform lamina according to the plane of cutting. By moving slightly the transparent cubes in Fig. 10 one could get the reversed pictures. A cut could have passed nerve-bundles in the cribriform lamina and septa of connective tissue in the optic nerve. In Figs. 11 and 12, the sharp back outline of the cribriform lamina is missing. Transverse fibres of connective tissue run across nerve-bundles in a similar way in the optic nerve as in the cribriform lamina. In Fig. 13, the lamina cribrosa seems to be composed of several levels. In Fig. 14 the cribriform lamina is hardly to be seen. Transverse fibres of septa run rather across the optic nerve.

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CONTACT LENSES *†

BY

IDA MANN

OXFORD

To us all here the subject of contact lenses is an interesting one and the foundation of a society for the scientific study of the problems connected with them needs no apology, but we are far from being a representative gathering. You will realise this when I tell you that only a short time ago an eminent scientist said to me "Why waste your time starting a contact lens society?" I replied "Why is it a waste of time?" and received the devastating answer, "Because everything is known about them. Optically they provide a beautiful answer to many problems and practically they are useless, as no one can wear them for more than an hour and a half." I think we can say that this statement is largely untrue. In the first place, I hope to show in this address that we certainly do not know all about them and, secondly, I think no one here will dispute the fact that some people cannot even wear them for an hour and a half, while others notice no discomfort after ten times as long.

There would, therefore, seem to be good reason for a society for their study, even though so much has already been written on them and so many experiments performed. These experiments differ from the usual scientific experiment in that they have practically all had to be done on man. Animal experiment will not give us any of the answers we seek, since obviously we cannot test visual acuity in

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† Presidential Address delivered to the Contact Lens Society.

an animal, nor can we enquire as to tolerance. Even gross experiments on corneal physiology are hardly applicable, the relative sizes of cornea and sclera differing between man and most other animals, as also does the anatomy of the limbus. We are, therefore, handicapped from the beginning by the introduction of innumerable variables (*e.g.*, of physiology, of pathology and of psychology) into each individual experiment and it is small wonder that, more than a hundred years after Thomas Young's original paper in the Philosophical Transactions, our knowledge is scanty and our chances of success in a given case still unpredictable. It should be the object of this society to formulate the problems which confront us and by the careful accumulation of accurate data to attempt to solve them.

It is obvious that our problems fall into two groups, those of optics and haptics. The former are not formidable and I do not propose to deal with them in detail, though you will all realise that much still remains to be done if we are to reach an optical accuracy comparable to that obtained with spectacle lenses. We have by no means mastered the problems of the introduction of prisms and of cylinders into contact lenses, nor are we very near the production of a bifocal contact lens. We are not even certain of the best material of which to make contact lenses, nor even whether that material yet exists. There is, therefore, room for collaboration with the physicist, the technician and the chemist.

The more pressing problems, however, are those concerned with tolerance. My own interest in the subject is purely clinical, and I have been ordering contact lenses more or less hopefully for the last ten years. Recently I realised that I knew very little about the results I had obtained and through the kindness of one of our secretaries, Mr. Cross, I was able to obtain a fair follow-up of 100 of my cases. This has been most illuminating, and has helped me to formulate some of our problems. All my cases were individually fitted, some of them after having tried Zeiss lenses with no success. In practically all of them contact lenses gave a better visual acuity than spectacles and were ordered for this reason. (I did not, in this follow-up, include cases with active pathological conditions necessitating contact lenses as part of treatment). The patients therefore had an incentive to persevere. Of the hundred patients, 61 were myopes, of whom 11 only wore $-5{\cdot}0$ D.Sph. lens or under, the rest having very high corrections, up to -22. The patients wore a single lens only, for monocular aphakia. Eleven had conical corneae and the remainder suffered from various disabilities, including high hypermetropia, binocular aphakia, corneal scars and dystrophies.

There were 46 males and 54 females and their ages ranged from 14 to 73 years. The majority were between 30 and 40 years old.

These patients were all asked whether, knowing what they now

know, they would go in for contact lenses again. Sixty-four replied unhesitatingly Yes, 19 gave an equally emphatic No, while 17 considered that certain improvements ought to be possible to make them comfortable and if these were done they would answer Yes. Can we discover any relationship between the tolerance and intolerance of these patients and either their ocular condition or their habits of wear? In the first place, must the lens be worn every day for tolerance to be good? Fifty-five patients wore their lenses every day and 47 of these had tolerance good enough to permit a full day's work in the lenses, 31 of them wearing them for more than 12 hours every day. The remaining eight (of the 55) had poor tolerance of less than six hours. On the other hand, nine patients who only wore their lenses occasionally had excellent tolerance also, so that regular wear is not proved to be essential. Most of the patients, however, who only wore their lenses occasionally had poor tolerance and gave this as a reason for not wearing them. Twenty-three of the 100 patients did not wear their lenses at all, but this was not always because of intolerance. In one case the patient's fingers were too rheumatic to manipulate the lens, in two cases a very dirty job was being done and they feared to put their dirty fingers near their eyes, in three others there was nervousness of the lens, but in many there was extreme intolerance.

Can we show that intolerance is associated with any special condition of the eye? If we consider the myopes we find that of the 61 questioned, 31 wore their lenses for more than eight hours every day, 16 wore them every day, but for less than eight hours, while 14 did not wear them at all and 10 of these 14 were high myopes who had much to gain visually. It does not therefore appear possible to relate tolerance to the presence or degree of myopia.

On the other hand, there does appear to be a correlation in the case of conical cornea, though the numbers are small. Of the 11 patients fitted, nine wore their lenses all day with success, and two could only wear them part of the day. None was a complete failure.

Monocular aphakia, though theoretically a good indication for contact lenses, does not in my series justify itself. Only two out of 10 patients wore their lens at all and one of these has now given it up. The remaining eight all complained of diplopia.

Of the cases with various corneal conditions, only four or five had really good results, but this series is small and not homogeneous.

We therefore require more data on the type of condition suitable for contact lenses and it might well be that a correlation with tolerance is not possible.

Eighty-four of the patients replied, when asked whether they inserted their lenses dry or used a solution. Much has been written

and many theories advanced about the necessity for a solution and its ideal composition. The results in my series are surprising and show that much more work is needed and that theorising is unsatisfactory. Of these 84, 49 inserted their lenses dry and 23 of these had a tolerance of more than eight hours (often 14 to 16 hours); eight of the 49 had tolerance of four to eight hours and 10 of from two to four hours. Eight could not wear a lens at all. Twenty-two patients used normal saline. Seven of them had more than eight hours tolerance, eight of them four to eight hours, four of them two to four hours and three could not wear the lens.

The third group is, however, the most interesting. Thirteen patients had obviously experimented and with surprising results. One with 16 to 18 hours wear every day always puts his lens in his mouth before inserting it, one with eighteen hours used distilled water, as did another with very poor tolerance. One used boracic lotion and wore the lens six hours, nine used tap water and all had tolerance of eight to sixteen hours. We have obviously a lot to learn and unlearn about solutions.

What reasons were given for intolerance? In many the corneal veil was the most trouble and this was too variable for generalisation, coming on sometimes in half-an-hour, sometimes in 14 hours. In other cases pricking of the lids, smarting, grittiness, discharge, headache and many other symptoms were noted, and here we have our greatest problem. The problem of the veil is basically a physiological one and will probably be solved by some modification of fit, as is being shown by Dallos' experiments with holes and slits in the lens. But there are other problems connected with the state of the lids and the presence or absence of low grade infections. A whole series of experiments awaits an investigator here, many even applicable to animals. We have no idea of the alterations of the normal bacteriological flora of the eyes produced by contact lenses. Indeed, the surprising thing is the high local immunity of the conjunctiva and the rarity of serious infection. Low grade infection may be common; we do not know. It may account for sensations in the lids and for the accumulation of sticky secretion complained of by some patients.

So far, you will note, I have not touched on the question of fit at all and yet have raised a number of unanswered questions.

I will leave it to our next speaker to attempt to clarify our ideas on the problems of shape, size and fit, and will be content to close this very incomplete list of unanswered queries with a plea for the accumulation of more data and the planning of further experiments. I trust I have justified my contention that the scientific study of contact lenses is not a waste of time.

POST-OPERATIVE SECURITY IN CATARACT CASES

BY

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THE simple procedure described below was devised to meet the case of an old lady of over eighty, whose mental and physical "wanderings" during her first night in hospital—where she had come for an extraction of one of her bilateral cataracts—gave rise to much foreboding as to her post-operative nursing.

The usual methods of trying to secure sound protection for the eye and the wound, were all thought of and discarded for various reasons: corneo-scleral suturing meant later removal of the suture, and did not seem to give the maximum security which one was aiming at; the van Lint flap had always appeared to me to give a line of tension across the middle of the cornea along the edge of the flap, and it seemed difficult with this method to get pressure to bear evenly on the wound, cornea, and sclera.

Finally, it was decided to try a complete conjunctival flap, *i.e.*, involving the whole circumference of the cornea. Accordingly, after the usual surface anaesthesia combined with retrobulbar injection anaesthesia and 7th nerve block over the mandible, a snip was made with scissors in the conjunctiva at the corneo-scleral margin to the outer side, a Weber's knife was inserted, and with the conjunctiva held taut with forceps at intervals all the way round, the conjunctiva was cut round the cornea. It was then undermined freely, and with 4/0 catgut, a purse string suture was run round the conjunctival edge—the two ends being at 5 and 7 o'clock. The conjunctival flap was now gently retracted away and a simple corneo-scleral section was made and, after iridectomy, the lens was extracted in capsule. The iris pillars were stroked back, and then, with the conjunctival margin helped over the wound with a couple of iris repositors, the purse string suture was drawn tight and tied gently but firmly. The whole cornea was thus covered with conjunctiva, and the general appearance gave one a most unusual feeling of security. The one eye only was bandaged, and the patient walked back to bed, and was ambulatory from the first day.

The suture started giving on the 3rd day, and the whole cornea was clear on the 14th—an unusually long period compared with succeeding cases. The whole convalescence was uneventful, the only treatment being my usual one of gtt. penicillin in flavazole, and gtt. atropine sulph. instilled every other day, and a daily inunction of ung. hydrarg.

Following this case, I carried out the same procedure in eleven

more cases. Out of this total of twelve cases done in the last 4 to 5 months—eight were intracapsular extractions, and four extracapsular. In one of the intracapsular cases there was some vitreous loss after the lens was extracted, but in neither this case nor any of the others were there any unusual symptoms, and the end results were excellent.

In the last eleven cases before the suture was finally drawn tight, gtt. penicillin and gtt. atropine were instilled into the mouth of "the bag." A small point which led to a little trouble with fixation of the eye in the first case, was that a small tag of conjunctiva should be left on the corneal margin at the point the operator usually prefers to place his fixation forceps—otherwise he finds it difficult to grip the eye without doing so on one of the recti muscles.

The suture was usually found to give about the 4th or 5th day, and the conjunctiva had retracted to the corneal margin by the 6th or 7th day. In only one case—for ultra-aesthetic reasons—was it necessary to help the conjunctiva back into place at one point on the 10th day.

The method is admittedly more tedious than the usual ones in vogue, but the feeling of complete security is very real. The purse string suture is easy to draw tightly and snugly, and the pressure over the whole cornea and wound is even and firm. The physiological conditions for wound healing are therefore ideal inasmuch as it is covered, supported, warm and sheltered from infection.

The fact that the patients can be ambulatory with safety after the first twenty-four hours is a marked advantage in these days of depleted nursing staffs, and any post-operative complications which may arise—with the exception of infection—are in effect dealt with before they happen.

I very much doubt if this procedure is original since nearly everything has been tried sometime, but I have not seen any reference to it in the literature available to me, and it is presented in the hope that it may be found to be a useful addition to the usual methods.

THE POWER OR "POWERS" OF A LENS

BY

JOSEPH I. PASCAL, M.D.

NEW YORK

IF a doctor at an Ophthalmological Board examination were asked, "What is the power of the crystalline lens?", he might well ask which of the different "powers" of the lens was wanted. *In situ* the lens may be said to have three powers, based on actual focal

lengths, *i.e.* the principal power, the vertex power, and the apex power. Placed in air it is very much more powerful, and again may be said to have three powers, the principal power, the vertex power, and the apex power. But in addition, and this is the most important point, *in situ* the lens has also a "reduced" power. This is the power as determined by the reduced focal length. This latter power is the real significant power and the one used by Gullstrand in his calculations of the dioptric power of the eye.

The definition of surface power and lens power, following the lead of Gullstrand, is based upon "reduced focal length". The power in dioptres is the reciprocal of the reduced focal length. The two actual focal lengths of any optical system are equal, when the first medium (or its index of refraction) is the same as the last medium (or same index of refraction). The two focal lengths are unequal when the first and last media are different. But in either case, there is only one reduced focal length. The refractive power of the system can be expressed by a single value, the reciprocal of this focal length, even when there are two actual focal lengths as in the case of the cornea, or the eye as a whole.

The reduced focal length is simply defined as the actual focal length divided by the corresponding index of refraction. Thus if f_1 and f_2 express the two actual focal lengths of a system, the reduced focal length $f(r)$ is equal to f_1 divided by n_1 or f_2 divided by n_2. The whole subject of "reduced" distance, "reduced" light vergence, "reduced" focal length, etc. is something that is basic and merits the study of every ophthalmologist. Unfortunately, the subject is hardly touched upon in the standard books on ophthalmology. It is true that for a lens in air, the reduced focal length is equal to the actual focal length and its significance and use may be ignored. But when studying the dioptrics of the cornea or of the eye as a whole where the reduced focal length is not equal to the actual focal length, a knowledge of this subject is essential. Books which do not point out the difference between the two systems create for the student-reader unnecessary difficulties and sometimes confusion.

For example, in Duke-Elder's Text-book of Ophthalmology, vol. I, page 748, there are tables contrasting the finding of Tscherning with those of Gullstrand relative to the position of the cardinal points, the dioptric powers of the components, etc. of the schematic eye. The table gives Tscherning's figure for the refractive power of the crystalline lens (*in situ*) as 16·01 D. and Gullstrand's as 19·11 D. This apparently means that Gullstrand using different data for his calculations found the power of the crystalline lens to be 3·10 dioptres more than what Tscherning found. But there is no mention of the fact that Tscherning used "actual" focal length for his power determination and Gullstrand used used "reduced" focal length. In

fact, if the lens power as found by Tscherning be changed to "reduced" power it comes out even more than Gullstrand's, being 21·40 D. That is, the reduced power of the crystalline lens, using Tscherning's data for radii, indices and thickness is more by 2·29 D. than the value found by Gullstrand.*

The method of calculating reduced surface power directly is very much simplified by what has been called the "dam" formula, D = aM. Here D stands for dioptres of power (reciprocal of "reduced" focal length) "a" stands for the difference between the two indices, (*i.e.* "a" *a*mount 2nd index is *a*bove 1st index) and M stands for curvature in metrecs. The latter is obtained by dividing the radius into 100, or 1,000 or 40 depending upon whether the radius is given in cm. in mm. or in inches.

As an illustration we may apply this formula to finding the "reduced" power of the crystalline lens, using Tscherning's data which are as follows: $r_1 = 10{\cdot}2$ mm., $r_2 = 6{\cdot}22$ mm. $t = 4{\cdot}06$ mm. n of lens = 1·42, and n = of aqueous — vitreous equals 1·3365.

For first surface $D = (1{\cdot}42 - 1{\cdot}3365) \times \frac{1{,}000}{10{\cdot}2}$; this works out to 8·19.

For second surface $D = (1{\cdot}3365 - 1{\cdot}42) \times \frac{1{,}000}{-6{\cdot}22}$; this works out to 13·42.

The sum of the two surface powers is 21·61 D. The effect of thickness reduces the total power by 0·21, giving a power of 21·40 D.

RESTORATION OF THE CHAMBER AFTER INTRA-CAPSULAR EXTRACTION

BY

Prof. A. KETTESY

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IT is well-known, since doing intra-capsular cataract extraction that we see delayed restoration of the anterior chamber more frequently than before.

This complication in the after-treatment has generally no significance at all, more properly, less significance than in the extra-capsular extraction, when there is the possibility of capsular or cortical particles left in the section. Nor has it any significance after the intra-capsular extraction either, if a shallow chamber is present if for only a short time. The well-known and easily

* The illustration taken from Duke-Elder's work is not meant as a criticism, but just to point out this omission even in the most scholarly and best known book on the subject.

verified causes of the temporary and periodic disappearance of the anterior chamber are delayed healing, re-opening of the wound, and choroidal detachment. The eye is soft, which is a re-assuring symptom.

But it happens also—luckily very seldom—that the chamber does not form at all; this very serious sign seems not to be appreciated in detail. The anterior chamber, after a smooth intra-capsular operation, without any discoverable cause, does not reform, leading eventually to the loss of the eye. The wound is well co-apted and closed, the eye is quiet, the palpated tension is normal, Seidel's test is negative, and there is no sign of glaucoma for the first 12-14 days. Then a fine haziness of the cornea appears as the first sign of glaucoma, the tension slowly rises to 30-40 Hg/mm. and without adequate medical aid the eye becomes blind.

In the last 20 years I have lost 2 eyes in this way, in spite of having performed in the second case posterior sclerotomy, cyclodialysis and trephining. The chamber could not be restored. (As I do an average of 250 cataract operations a year, including about 200 intra-capsular extractions, this makes together with the case described below 0·7 per cent. of the intra-capsulars for the last 20 years).

It was by chance that a third case showed the way to restore the anterior chamber and gave also a possible explanation. Intra-capsular extraction was performed on both eyes of an old lady. It was a straightforward case, without any sign of impending trouble. The operation was uneventful in both eyes with my routine procedure: Knapp-Stanculeanu-Török, iridectomy, conjunctival hooding of the wound, akinesia and retrobulbar injection. We instil as a rule pilocarpine after intra-capsular extraction.

No restoration of the chamber occurred in either eye. There was no irritation, the wound closed, and no hypotony. We waited 6 days for spontaneous restoration.

On the seventh day we started to do something for the restoration of the chamber. We instilled 8 per cent. pilocarpine together with cocaine and adrenalin, in order to raise the tone of sphincter and dilator simultaneously, a proceeding that leads sometimes to success. But in this case it failed, as well as repeating it with 1 per cent. adrenalin the next day.

On the ninth and tenth days we joined to the instillations intravenous injections of 40 per cent. dextrose in the hope of obtaining a result by dehydrating the vitreous, but in vain. Dionine powder into the conjunctival sac and sub-conjunctival injection of saline solution proved to be similarly inefficacious.

On the twelfth day after the operation the loss of both eyes seemed to be imminent, so we started operative interventions. Both wounds seemed to be well closed, palpated tension was normal, no lacrimation, vision good.

In remembrance of the uselessness of posterior sclerotomy in a similar case, I decided to do cyclodialysis on both sides, after the modification of Blaskovic's (*a tergo*) carried out in front of the external rectus.

The end of Heine's spatula, forcing its way during the operation into the chamber between iris and cornea, got into the pupillary area by mistake, and injured the hyaloidea. The vitreous streamed immediately forth, pushed the iris back and filled the chamber. The chamber was restored (of course a vitreous-filled chamber). Eye-surgeons see the same thing occasionally, when, during cataract extractions the hyaloidea is broken and vitreous fills the anterior chamber.

On the fellow-eye I brought about the same event on purpose. I pushed the point of the spatula into the pupillary area and broke the hyaloidea by a little movement sideways and backwards. The result was the same, the chamber was immediately restored.

The further course of the case was satisfactory. The palpated tension of the eye remained normal. taken by tonometer 6 days later it was 22 Hg/mm. Corrected vision 6/9 and 6/12. Slit-lamp examination showed the well-known signs of the vitreous-filled chamber: in the aqueous there were waving from the pupil ramifying fibres of the vitreous.

Since then I had no opportunity to perform this operation, that could be called restoration of the anterior chamber. It was only considered once, but the chamber restored itself spontaneously on the eleventh day.

The plain vitreous chamber has, as far as our experience reaches, scarcely any significance regarding post-operative glaucoma. It is true, text-books mention the loss of vitreous and the absence of the hyaloidea amongst the causes of post-operative glaucoma, but there are also plenty of observations to the contrary. Yet, admitting the possibility of bringing about the danger of later glaucoma, this is a small drawback in comparison to the direct and rapid loss of an eye after the operation.

It is interesting to note that the whole vast literature of cataract-extraction does not mention the primary, nor glaucomatous non-reappearance of the chamber, only the prolonged restoration. Of course, it must have been very rare in the pre-intracapsular period, and whenever it occurred, it was traced back to non-closure of the wound, to epithelial immigration and chiefly to an unobserved glaucomatous tendency, promoted by the operation. Though the latter possibility cannot be rejected with absolute sureness, I am convinced, in my cases there was no primary glaucomatous disposition. It seems to me more probable, the cause was purely mechanical. The iris was flat, adhering to the cornea, the pupil

was tightly filled with the inelastic hyaloidea, capillary adhesion closed up the chamber completely. Under such conditions spontaneous reversibility is hardly imaginable. The retained aqueous must be taken up by the vitreous, its swelling presses iris and hyaloidea the more to the cornea: a vicious circle thus arises which can be interrupted only by operative intervention. A similar situation is well known, of course only after glaucoma operations when it is the lens, that obturates the chamber. There is also an account of trying to restore the chamber in such cases. Asayama and Chikakiyo blow air between iris and cornea if after Elliot's trephining the chamber will not reform (*Zentralblatt f. Ophthal.*, Vol. XLII, p. 599).

ANNOTATIONS

Neuro-paralytic Keratitis

Although alcohol injection of the Gasserian ganglion is a strikingly successful form of treatment for trigeminal neuralgia, the patients who submit to it are always haunted by the possibility of developing lesions in the anaesthetic cornea which, if untreated, may lead to serious consequences involving, sometimes, corneal perforation, and loss of the eye. The cause of the condition has been a subject of discussion among physiologists for many years, one group maintaining that the cornea has trophic nerve fibres which in some mysterious way look after its nutrition, and that when these fibres are blocked or severed, the cornea suffers; the other group maintains that anaesthesia of the cornea is sufficient reason for its breakdown, minute traumata occurring, unnoticed by the patient but leading to subsequent keratitis. This has always seemed to us an unsatisfactory explanation, in view of the fact that the earliest observable change in the cornea consists of the development of numerous pinpoint areas in the exposed part which stain with fluorescein, and it is difficult to imagine any form of trauma which which would produce this.

The only method of treatment until recently has been to provide some sort of cover for the cornea. The ideal cover is, of course, the lids, and for many years now the operation of tarsorraphy has held the field, with resulting inability to use the eye. This disadvantage can be mitigated by gradually dividing the adhesions once the cornea has regained its normal state, and it is frequently found that an adhesion only 3 mm. wide lying over the outer limbus is enough to maintain integrity of the corneal epithelium. Even this, however, constitutes a fairly conspicuous disfigurement, so other methods have been sought for. The application of a pad is dangerous

because the patient may unconsciously open the eye underneath it and inflict severe trauma on the cornea.

A method described by Klein consists in the use of a plastic contact lens. He claimed several successful results, but there is always the possibility of the patient injuring the anaesthetic eye when inserting the contact lens, and perhaps not getting it into the correct position. We have known of one case in which the patient allowed the lower ledge of the lens to project over the lower lid. If an extrinsic protection is to be provided it should take the form of a rigid and preferably transparent shield, with sufficient bulge on it to stand well away from the eye and not come into contact with it, even if the patient lies on the shield during sleep. If facial paralysis is also present, as sometimes happens in other neurological conditions, then it must be air tight so that moisture is retained, but this is not necessary in ordinary trigeminal cases when sensory denervation alone has to be considered.

One hopes that these methods of treatment will soon become matters of historical interest rather than current procedures. Many years ago Mackenzie of Toronto described the effect of sympathectomy in causing healing of ulcers of the face after trigeminal denervation, and Norman Dott has found that it causes rapid healing of trophic corneal, nasal or other ulcerations of the skin dependent on trigeminal denervation. The effect lasts for many years, possibly indefinitely, and he is now in the habit of doing a prophylactic sympathectomy before or after alcohol injection of the ganglion. None of the cases treated in this way has so far ulcerated.

This procedure is not, of course, required in cases of trigeminal neuralgia where the first division is not involved because in them, by fractional section of the sensory root of the 5th nerve, it is possible to retain sensation in the eye and lids.

On observation

We do not hesitate to affirm that good powers of observation are among the most important items in the outfit of any member of the medical profession. Students should be taught to cultivate the faculty from the start of their careers and the practice should be kept up and not dropped as soon as the qualifying exams have been surmounted, for no one will deny that in our profession we remain students all our lives. The youth of the writer's generation had the importance of observation powerfully instilled into their minds by those admirable Sherlock Holmes stories of the late Sir Arthur Conan Doyle. Holmes was never at fault in his observations and Sir Arthur was a born story teller. One of Holmes' remarks that has always stuck in our mind was to the effect that a man's brain was like a room of limited capacity, and that the wise man only took

into it information that was likely to be of use to him in his work and did not get it cluttered up with odds and ends, which, however interesting in themselves, would crowd out more useful facts. John Hunter must have meant something of the sort when he declared, after coming down from Oxford, that they had tried to stuff him with Latin and Greek and make an old woman of him.

Of those ophthalmic surgeons we have known we should place the late Mr. William Lang as nearest the Holmes ideal. Mr. Lang was phenomenally observant and never seemed to miss anything. A friend of ours used to declare that in his early days in ophthalmology he made a habit of accompanying a clinical assistant to the hospital each day, and they used to award marks to each other for any ocular condition they observed in people in their walk. Gross cases of squint would be marked at the figure 2, less marked strabismus might count 5, an empty socket 1, but a well fitting glass eye 10 and so on.

There is something to be said for the idea and it need not be confined to eye conditions. A person who limps in his gait may have several possible conditions, including corns to account for it. Even in reading a book there are opportunities for cultivating mental observation. We wonder if the average reader of Pickwick has noted the fact that on Mr. Peter Magnus's first appearance he was wearing blue spectacles and, that when he was introducing Miss Witherfield to Mr. Pickwick next day, the spectacles had changed to green? Even the worthy Dr. Watson suffered from an Afghan bullet in his shoulder in one work of fiction by Doyle and in his leg in another.

BOOK NOTICES

Eye Manifestations of Internal Diseases. By I. S. TASSMAN. Second edition. 614 pp., 243 illustrations, including 24 in colour. Published by Henry Kimpton, London. 1946. Price, 50/-

Many ophthalmologists will be pleased to see the second edition of Tassman's book on the ocular manifestations of general diseases. It will be remembered that the book is intended to meet the needs both of the ophthalmologist and the general physician, and it is indeed extraordinary how much of ophthalmology can be included within this scope. After an introductory part describing the normal structure of the eye and its routine examination in a simple manner to suit those not experienced in ophthalmology, two chapters follow dealing cursorily with structural abnormalities and congenital and hereditary manifestations in the eye. Then follow chapters on the ocular complications of general infections of all types including bacterial, virus, fungus and parasitic infections, intoxications due to

drugs and chemicals, cardiovascular, haematogenous, metabolic and endocrine diseases, avitaminosis and disturbances of nutrition (which, surprisingly perhaps, include botulism), central nervous diseases, diseases of the skin, and of the bones of the skull. It is obvious that the scope of the book is very large, embracing practically the whole of ophthalmology, and its value as a source of reference is considerable, the emphasis being placed throughout on the ocular manifestations of the disease and not on a description of the general aspects of the disease itself. The text has been brought considerably up-to-date in this edition and several new additions appear—ocular allergy, epidemic kerato-conjunctivitis, Hurler's disease, lymphogranuloma venereum, Bowen's disease and toxoplasmosis, to mention a few. The greatest deficiency of the book is perhaps the lack of sequence and correlation between different conditions. Thus epidemic kerato-conjunctivitis is treated as a new specific entity without any correlation with other related conditions such as superficial punctate or nummular keratitis while the common development of disciform keratitis from virus infections is unstressed. On the whole, however, the book is a valuable addition to any ophthalmological library.

Diseases of Children's Eyes: By JAMES HAMILTON DOGGART. 288 pages with 210 illustrations including 32 coloured plates. Henry Kimpton, London. 1947. 42/-

A book devoted entirely to the eye diseases of children is unusual. It is, however, by no means out of place for there is much in ophthalmology, as indeed in the whole of medicine, that is peculiar to the young. The methods of examination are to a large extent specialised with their necessary dependence on objective testing; to some extent the anatomy is specialised (as witness the development of the air sinuses); congenital deformities—a common and striking aspect of ocular pathology—are prominent in the problems involved; certain diseases are peculiar to childhood, and many problems—particularly those of squint—assume unusual importance in this stage of life. It is true that to some extent the aspects of some of these problems as applied to children lose their perspective in many text-books and courses of systematic teaching, but it is more important that their urgency is often forgotten by the family physician and sometimes by the paediatrician. In so far as it will tend to emphasize this aspect of ophthalmology, Doggart's book is welcome and useful.

The book itself is comprehensive. It opens with an outline of the general principles of examination and a discussion, occupying four chapters, of the anatomy of the eye and its adnexa. It may be questioned whether in a book of this type so much elaboration of this section is necessary; the student of ophthalmology will get it elsewhere, and the physician may be overburdened with detail. The

next four chapters deal comprehensively and well with the development of the eye and its adnexa and the congenital abnormalities which affect these structures. There follow chapters on the ocular complications and sequelae of systemic diseases in childhood, methods of treatment and the principles of ocular welfare in the young—special schools, lighting conditions and ocular hygiene generally. The chapter on refraction contains sound advice on the inadvisability of debarring myopic children from reasonable educational development. There are five chapters on disorders of ocular motility (heterophoria, convergence defects, squint, nystagmus, etc.) and the remainder of the book concerns itself with a brief description of the commoner diseases of the various structures of the eye, the orbit and the lacrimal apparatus.

The author has had a long experience of ophthalmic problems in the young through his association with the Children's Hospital, Great Ormond Street, London, and the book bears ample evidence of his sound appreciation of the problems involved. There are few faults in detail—recent research, for example, is not represented in the delineation of the pupillary paths—and its general philosophy and teaching, although some of the opinions expressed are personal, are of great interest and value. The book is beautifully produced despite the difficulties of the time and amply illustrated. Both publisher and author are to be congratulated.

A Treatise on Gonioscopy. By MANUEL URIBE TRONCOSO. P. 306. 117 illustrations, 35 in colour. Published by F. A. Davis, Philadelphia. 1949.

Although Trantas in 1892 succeeded in examining the angle of the anterior chamber with the ophthalmoscope by employing finger pressure over the outer part of the limbus in cases wherein it was especially deep, and Mizuo in 1914 obtained a distorted view of the lower part by filling the inferior fornix with water, the first adequate examinations were made by Salzmann in 1914 who used a contact glass and direct ophthalmoscopy and Koeppe who used it in combination with the slit-lamp. These pioneers laid the foundation of our clinical knowledge of the vagaries of the angle, but it was not until Troncoso of New York introduced his gonioscope in 1925 — a microscope combined with a periscope — that this knowledge became exact and widespread and of clinical value. Previously the state and affections of the angle were interpreted in terms of microscopic sections, and many of the deductions as applied to the living eye therefrom have been shown to be erroneous. To-day a new branch of ophthalmic diagnosis has developed and become popularized, and sufficient observations have accumulated to establish its value and define its potentialities. It is opportune, therefore, that this knowledge should now be gathered together and summarized, and it

is fitting that the book should come from the pen of Uribe Troncoso to whose enthusiasm and immense capacity for patient and accurate observation gonioscopy owes its place in ophthalmology to-day.

Troncoso's book is a delightful one — well written, easy to read and full of interest. The first chapters are devoted to a description of the comparative anatomy of the angle in man, the comparative physiology of the outflow of the aqueous, and (written by Ida Mann) the embryological development of this region. There follow the story of the development of gonioscopy and a very clear and adequate description of the various techniques which have been used, a description of the gonioscopic appearances of the normal angle, and finally its abnormal appearances in senility, in congenital deformities, in injuries, inflammations, tumours, glaucoma (in great detail) in three chapters), in post-operative glaucomatous states and in various miscellaneous diseases. It is in glaucoma, of course, that the method has excited the greatest interest and is of the most clinical value: from the point of view of pathology it has demonstrated that peripheral synechiæ are the result, and not the cause of raised intraocular pressure, and has laid the foundation for a division (now becoming popular) of the disease into a wide-angle and narrow-angle type. From the clinical point of view the greatest value of the method is to suggest lines of appropriate treatment and to observe the efficacy of operation.

So clearly is the book written that it would be easy for the tyro to undertake gonioscopy with it alone as a guide. To a considerable extent this is rendered possible by the number and excellence of the illustrations, and further study is facilitated by the full bibliographies. Obviously Troncoso has enjoyed his life-work; his writing shows his enthusiasm and it will surely inspire others to profit by his experience, and advance still further a fascinating diagnostic technique.

NOTES

National Society for the Prevention of Blindness, Inc. Poster

AN attractive poster captioned "Seeing Through Life" is available from the National Society for the Prevention of Blindness at 1790 Broadway, New York 19, New York. Recently revised and reprinted in bright colours, the poster emphasizes the measures that conserve and protect eyesight from the pre-natal stage through old age. It is suitable for use in connection with health and safety education programmes. Size, 19×25; price, 30 cents per single copy, with reductions on quantity orders. If possible, remittance should accompany order.

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Corrigendum

IN the article on familial cataract, p. 391, the last word of the legend beneath fig. 7 should read extraction, not extension.